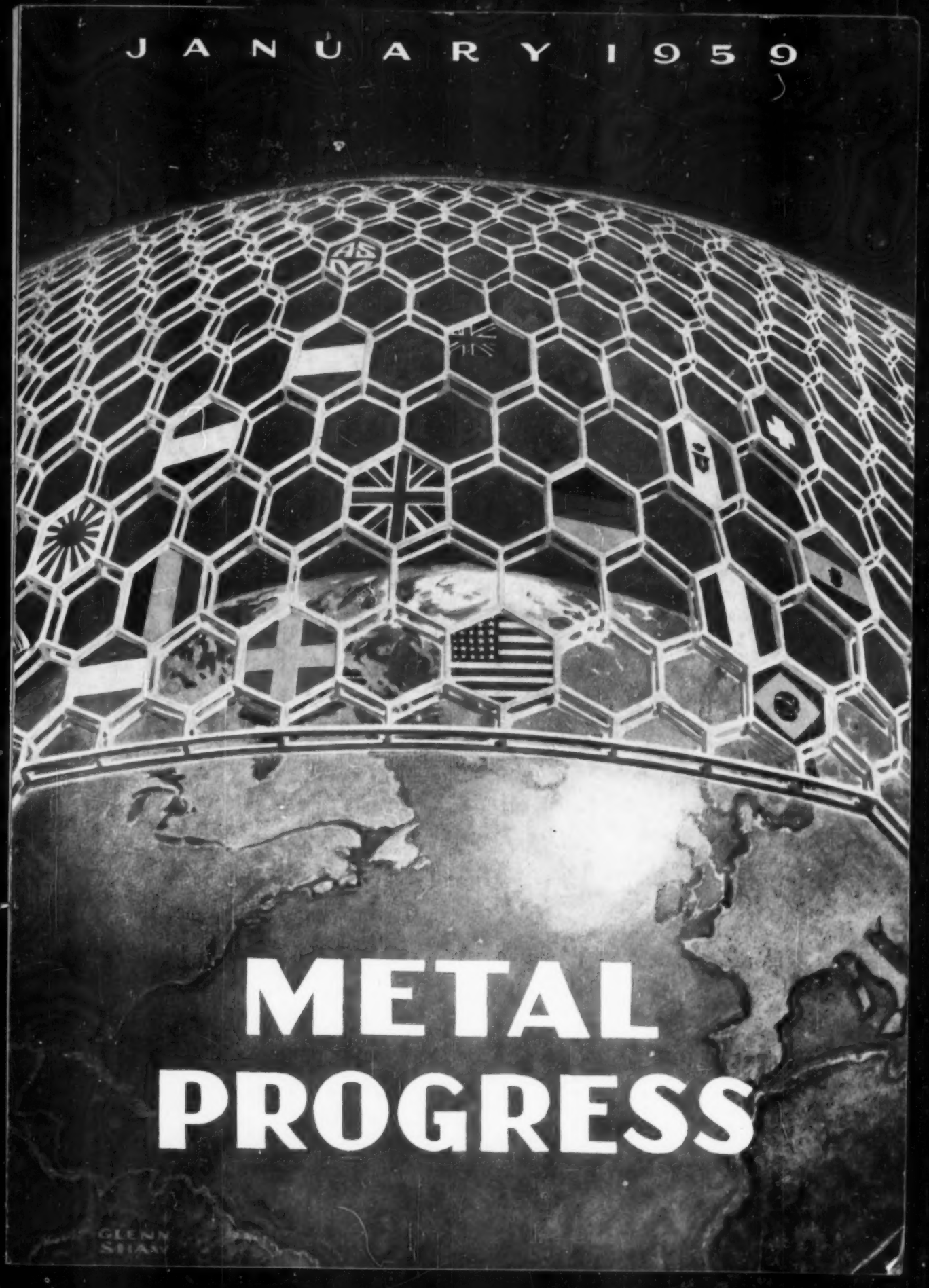
JANUARY 1959



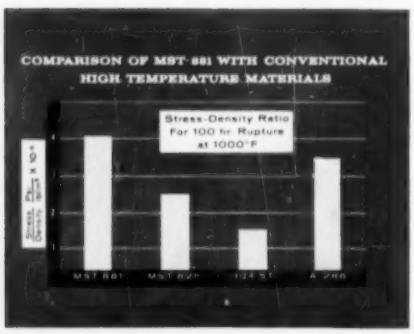
METAL PROGRESS

GLENN SHAW

New Mallory-Sharon 1100° Titanium Alloy

MST 881

BREAKS THE HEAT BARRIER


COMPARISON OF MST 881 WITH CONVENTIONAL HIGH TEMPERATURE MATERIALS
Stress-Density Ratio For 100 hr. Rupture at 1000°F
MST 881
MST 821
304 SS
A 286

Note high stress/density ratio of MST 881 at 1000° F., compared to MST 821 alloy, 304 and A 286 stainless steels.

Now, after 2½ years of intensive research, Mallory-Sharon has developed a new titanium alloy with elevated temperature properties far surpassing those of any existing titanium alloys.

At a temperature of 1000 degrees F., a level of increasing importance in the aircraft industry, MST 881 has *more than twice the creep strength* of any existing commercial titanium alloy. Even at 1100 degrees F., MST 881 will have only about 0.5% deformation at a stress of 25,000 psi.

What this means in terms of jet engine construction, for example, is illustrated above. The weight-saving advantages of titanium can now be obtained in additional stages of hot Mach 3 engines through use of MST 881.

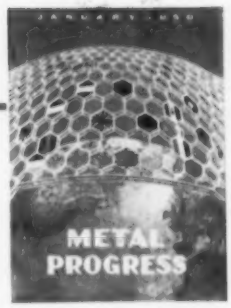
Write today for technical data sheet on MST 881.

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION · NILES, OHIO

Metal Progress

January 1959 . . . Volume 75, No. 1



The "space lattice" spanning the continents not only suggests the international flavor of this issue but also the aluminum dome of ⓐ's new headquarters building now under construction. Cover design by GLENN SHAW, well-known Cleveland artist.

Annual International Review of Metallurgy

Steelmaking Progress in Belgium and Luxemburg, by A. Decker 65

Such interesting results were obtained with the experimental low-shaft blast furnace that a large furnace has been operating economically on fine coke with 15% moisture. The new OCP steelmaking process injects a mixture of oxygen and lime powder through the mouth of a standard 30-ton basic converter. Slag is poured off after about 14 min. when carbon is down to 0.7%. The afterblow is timed by stop watch. Excellent steel and agricultural slag result. (D8n, D10; CI-a, ST)*

Architectural Metal at the Brussels Fair, by F. Charles Thum 71

Steel cables were widely used as main tension members from which roofs are hung, clearing the exhibit space of all supporting columns. Light and strong supporting members enabled the architect to use colored plastics effectively. Brilliant metal more than held its own in the aesthetic balance. (T26n, 17-57)

Metallurgy in Israel, by Ariel Taub 75

In the past decade, the number of metalworking establishments in Israel has more than tripled. Since they are nearly all quite small, they depend upon the Israeli Institute of Technology for engineering advice. About 400 undergraduate engineers are receiving instruction about metals. Furthermore, a department of metallurgy has been organized and is offering graduate work and university extension courses. (A3, A4, A6)

Welding and Metal Forming in Russia, by Arthur B. Tesmen 79

Electroslag welding is used to fabricate large parts from components while friction welding is claimed to be much more efficient than flash welding. The Soviets reportedly are constructing a 77,000-ton forging press and a 20,000-ton extrusion press which is considerably larger than similar equipment built for the U. S. heavy press program. (K6, F22, F24, W22p)

Metal Parts for Operating at Higher and Higher Temperatures, by D. A. Robins 84

Several hundred experts in the field of powder metallurgy gathered at Reutte, Austria, in June to discuss "High-Melting Metals, Their Manufacture, Properties and Applications". Columbium, molybdenum, tungsten, tantalum appear to hold most promise for the future. (H-general; EG-d37, Cb, Mo, W, Ta)

Anodizing and Coloring Aluminum in Britain, by Tom Bishop 87

Preferred anodic coating for architectural applications is 0.001 in. thick, but for some uses thickness of 0.0006 in. is satisfactory. Procedures are given for pretreatment, anodizing and coloring to produce a light-fast finish. (L19, T26n, 17-57; Al)

Atomic Energy in Canada, by David A. Keys 90

Canadian activities are restricted to peacetime uses of atomic energy. Over 100 "Cobalt-60 Theratrons" have been sold to 20 countries for treatment of malignant diseases. Long and successful experience with heavy water as a moderator for chain reaction in natural uranium enables them to use this principle in the design of their first power plants. (W11p, 1-52, 16-62)

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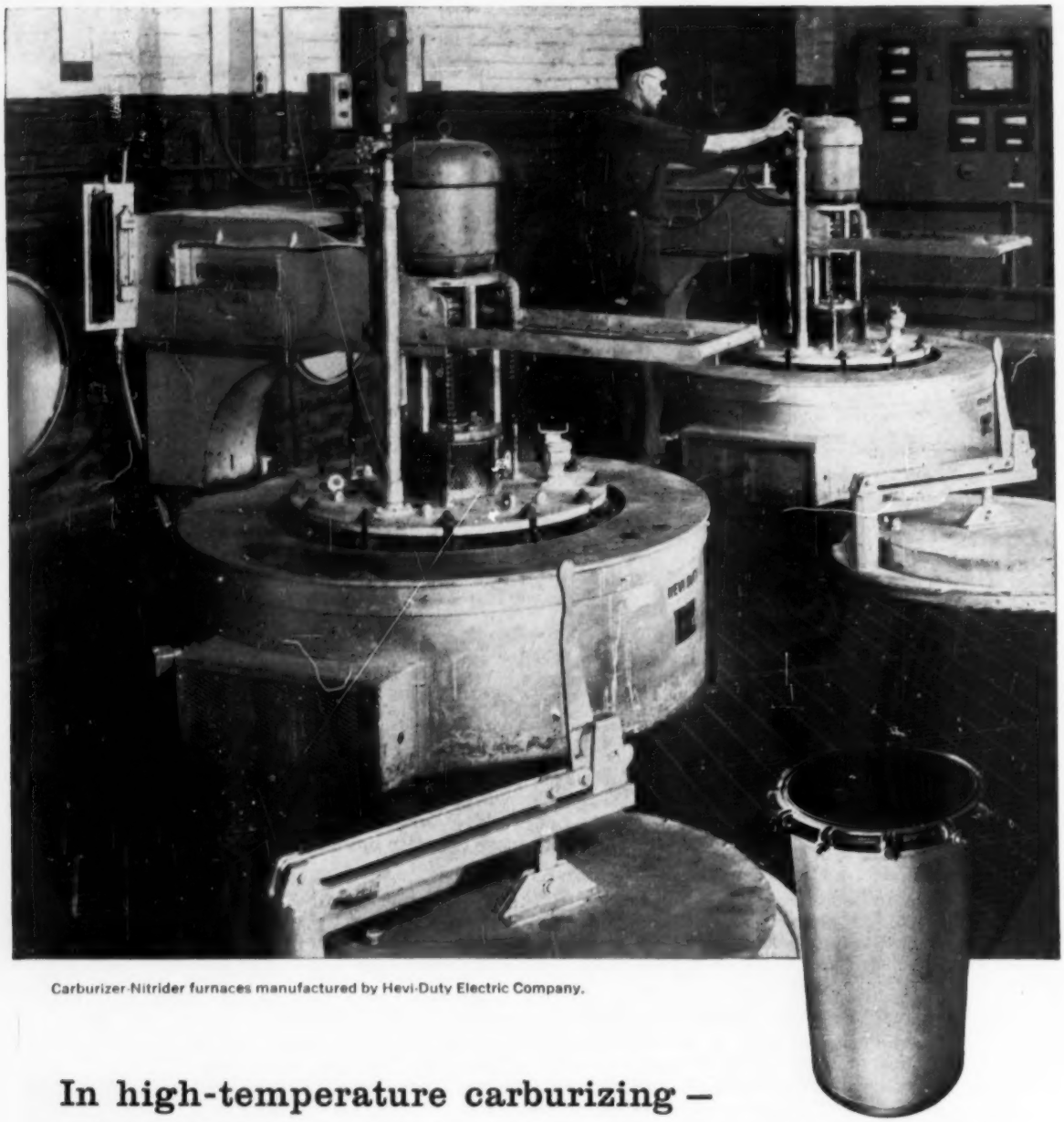
**The coding symbols refer to the ASM-SLA Metallurgical Literature Classification, International (Second) Edition, 1958*



Carburizer-Nitrider furnaces manufactured by Hevi-Duty Electric Company.

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Metal Progress

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The Institute of Metals... Its First 50 Years, by J. C. Chaston 95

First years were spent in establishing the research metallurgist's position. Now that the battle for recognition has been won, the Institute is expanding its activities in nonferrous metallurgy. Research is planned in many fields. (A2, A12g)

Controlled Atmospheres in Australia, by F. P. Heard 98

Limited gas sources make the production of adequate controlled atmospheres very difficult, but byproduct propane from newly built oil refineries appears to have solved the problem. An immense pool of natural gas under the Sydney area has also been considered as a potential source for controlled atmospheres. (J2k, B25)

Principles of Eddy Current Testing, by Friedrich Foerster 101

This versatile method of nondestructive testing is becoming more and more useful by the day. A defective sample will cause the impedance of a test coil to vary; these variations can be measured to determine several properties such as hardness, tensile strength, diameter, conductivity and permeability. (S13h)

More Atoms for Peace, by John P. Howe 106

Discussions at the Geneva Conference indicated that the knowledge of fundamental physics is more advanced than the ability to harness the atomic forces to desired ends, and that work in the latter field tends to be on *ad hoc* problems and is scattered and thin rather than concentrated and deep. (W11p, P18)

Metallurgical Fuel Developments – Main Lines of the Postwar Years, by D. W. Gillings 111

Extensive blending of high-volatile coal has enabled the supplies of acceptable metallurgical coke to be maintained as needed in Europe. Many British openhearths have been converted to oil firing practice for some years, while the adoption of electric melting for producing plain steels results from efficient power generation from low-grade coal. (D-general; RM-j, RM-k, RM-n, 16-61)

Progress in German Steelmaking, by H. W. Balster 116

Plants are being renovated and modernized from blast furnace to rolling mill. West African ore will supplement German reserves, blast furnaces will be using high pressures and oxygen, openhearth, electric and converter melting methods are constantly improved, and rolling mills are being mechanized. Economies all along the line continue to keep Germany high in steelmaking. (D-general)

Metallurgy in the U.S.S.R., by J. Herbert Hollomon 120

Russian production, abetted by highly respected scientists, threatens to overtake that of the free world. This challenge must be faced with enlightened technical leadership if we are to stay in front. (A-general)

High-Purity Metals in Commercial Quantities, by R. A. King 127

The Consolidated Mining and Smelting Co. of Canada Limited, long a producer of lead and zinc of 99.9% purity, has extended its operations to include the production of high-purity antimony, cadmium, silver, bismuth, tin and indium. (C-general, S11; Pb-a, Zn-a, Cd-a, Ag-a, Bi-a, In-a)

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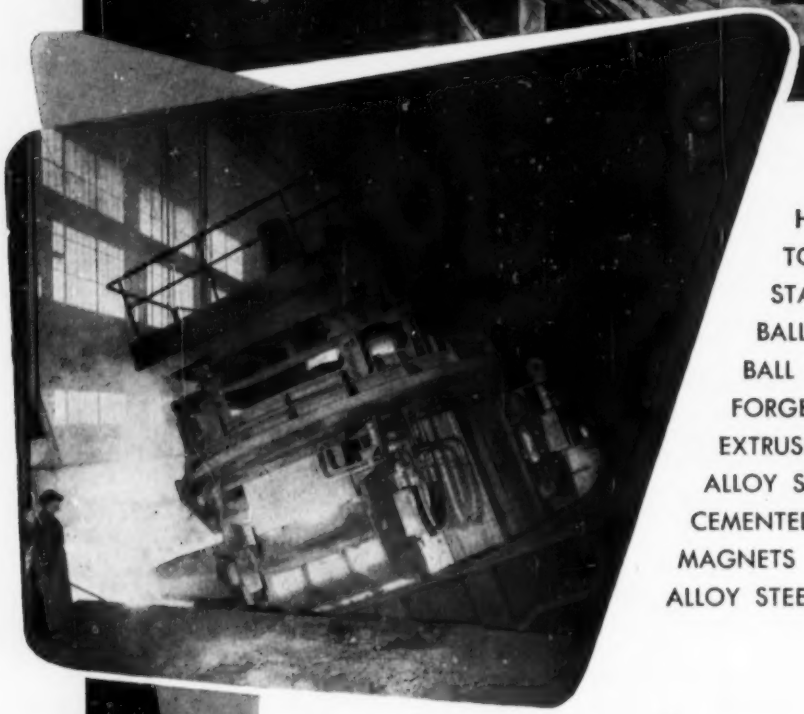

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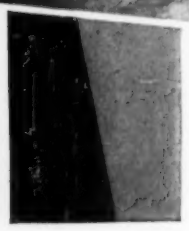

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Press Breaks...

CRISSCROSSING EDITORIAL PATHS converged in Washington the week of Nov. 17, when Editor-in-Chief Thum turned up for a meeting of his A.E.C. Advisory Committee on Industrial Information early in the week, followed by the Society of Business Magazine Editors meeting the last three days; Editor Gray attended the Advisory Committee one day and then went on to speak on Space Metals before the two branches of the ⊜ Carolinas Chapter; and Managing Editor Hyslop attended the week-long International Conference on Scientific Information. In the latter, experts from all over the world focused attention on the relatively new and rapidly growing science of documentation.

The principal job of the documentalist is to make published information more readily accessible to the scientist and engineer. Traditionally his tools are abstracts and indexes, but their inadequacy to cope with the outpouring of technical literature today has led to much talk – and some investigation – on the possibilities of using business machines and digital computers to facilitate literature searching – or "information retrieval", as the documentalists prefer to call it.

Again and again during the week's discussions our impression was reinforced that A.S.M.'s documentation activities are heading in the right direction – in fact are breaking the way. For example, one of the conclusions of the Conference was that pioneering work in mechanization must be done in a limited area on an experimental basis without waiting for a general information theory or the development of a system which would comprehend all scientific knowledge. This of course is exactly what is being done by the ⊜ Machine Searching Experiment at Western Reserve University.

Another recommendation of the Conference was that the most useful combination of tools for a field the size of metallurgy is a set of "indicative" abstracts accompanied by indexing in depth – and again A.S.M.'s projected service fills this specification. Plans are that the ⊜ *Review of Metal Literature* will continue to be a service providing *prompt* and *indicative* abstracts of the world's metallurgical literature; the searching service will be based on highly detailed and thorough subject indexing – "indexing in depth" as the saying is. The latter, of course, takes brains and skill; the machine can only sort and relate the information that has been previously analyzed and encoded into a form it can understand.

In still another way A.S.M. has pioneered in a service highly recommended at the Conference. This is the provision of indexing terms with each published abstract so that clerical help can scan the pages and select those abstracts which apply to desired subjects. Such indexing terms are provided by the ASM-SLA code symbols which accompany the annotations in the *Review of Metal Literature*, as well as the principal articles in *Metal Progress* and other A.S.M. publications. These cryptic combinations of letters and numerals appearing in the Table of Contents on pages 1 and 3 refer to the ASM-SLA Metallurgical Literature Classification. (A new International Edition has just been published.)

Documentation is a notoriously expensive business and seldom is self-supporting. The cost of preparing the *Review of Metal Literature*, for example, has doubled in the past three years. Consequently *Review of Metal Literature* and *Metals Review* are now separate publications – the former being sent at no cost to A.S.M. members who request it (with a $15.00 subscription fee to nonmembers); it is also being printed by more economical methods.

At the same time the budget for the searching experiment has been increased, with the hope that an operating service, limited to current literature, can be provided by 1960. Also a charge will be levied – at least until such time as another of the Conference recommendations can be put into effect, namely, that a part of every research budget should be clearly earmarked for "communications". Until that time, the user, along with service organizations such as A.S.M., must pay the freight.

THE EDITORS

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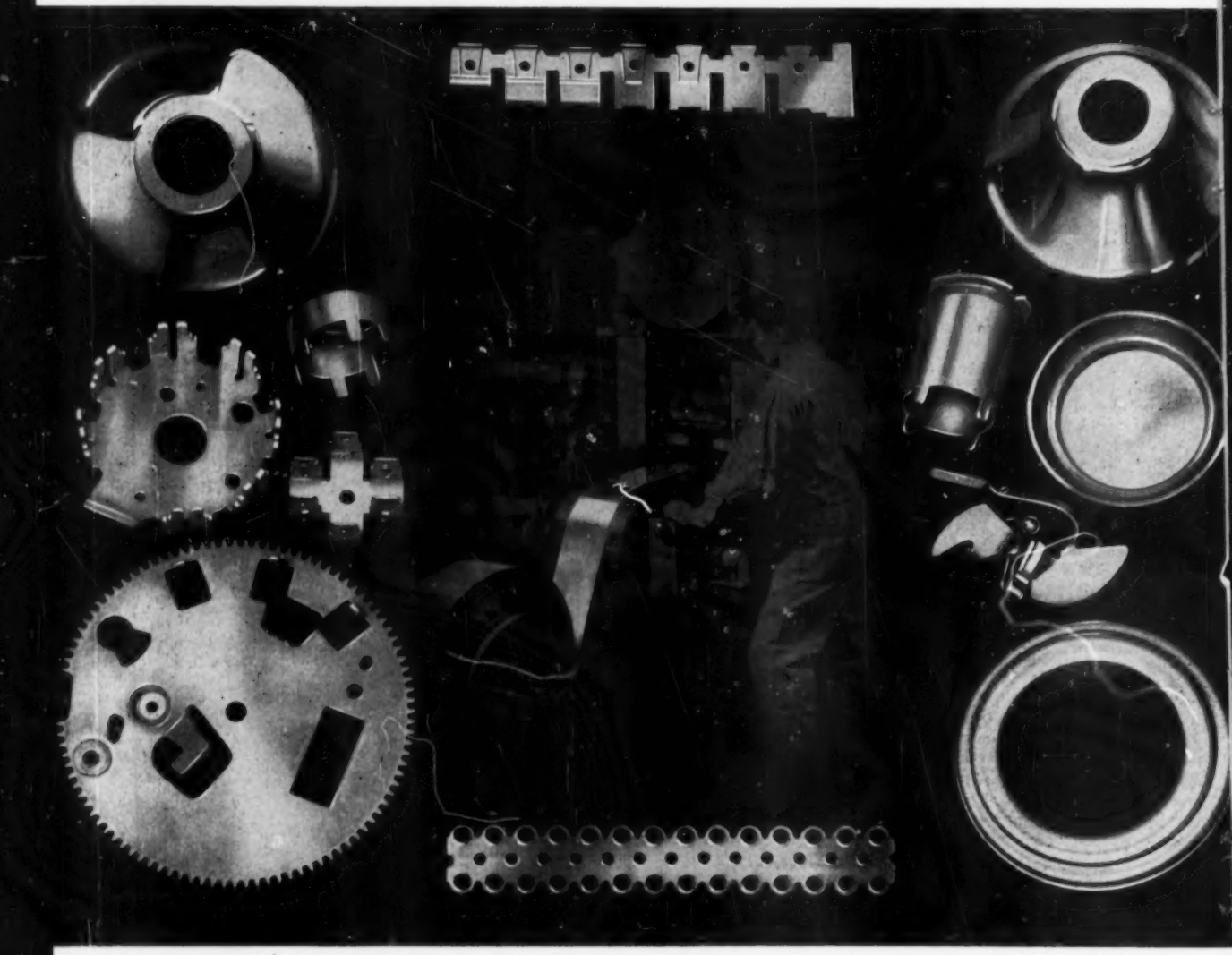

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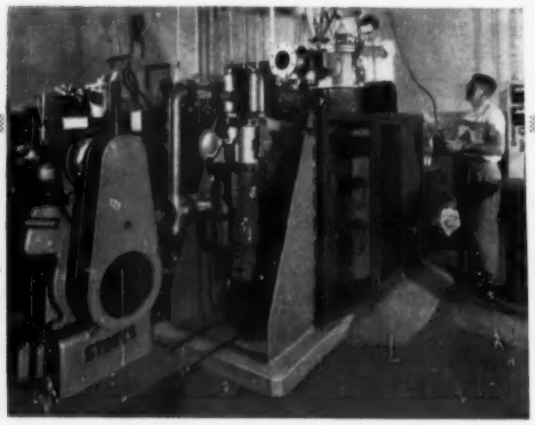

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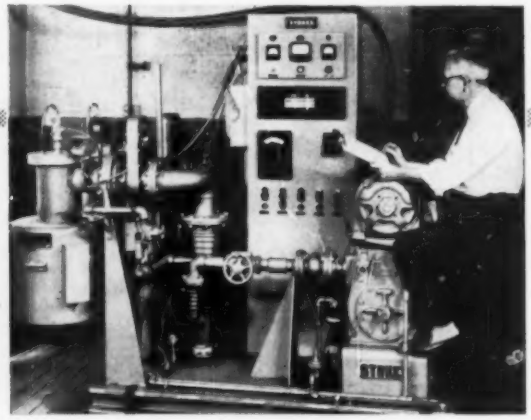

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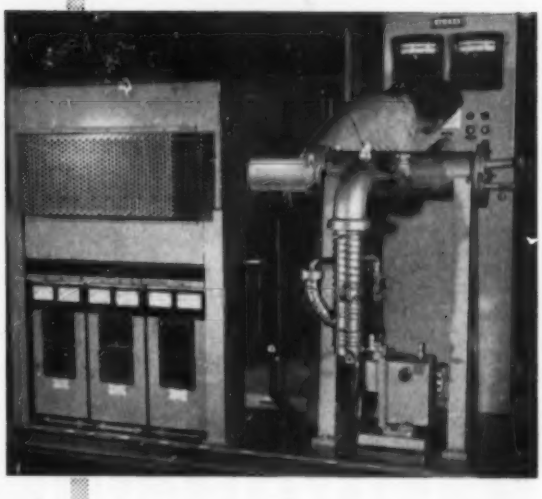

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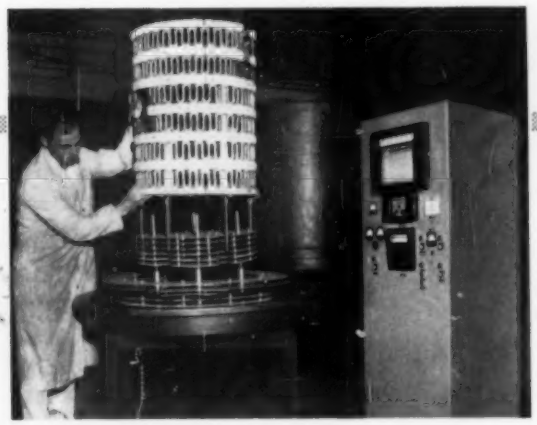

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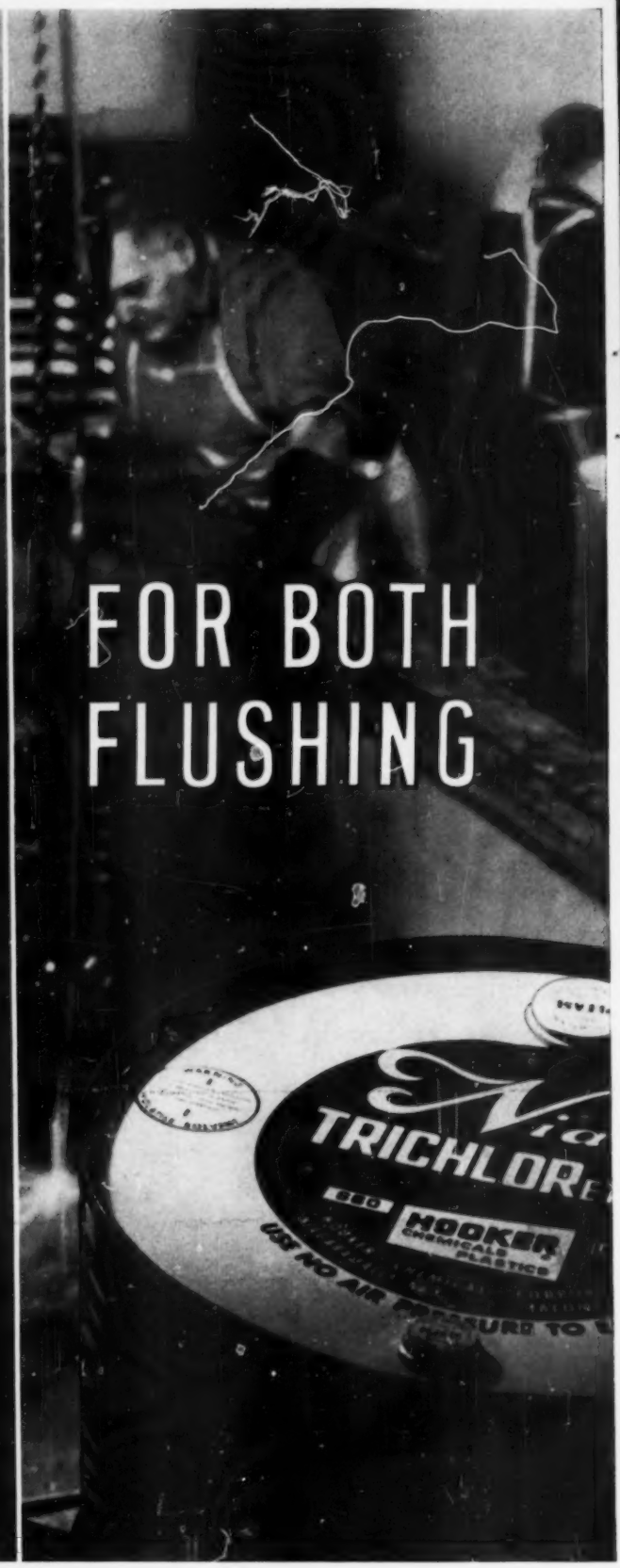

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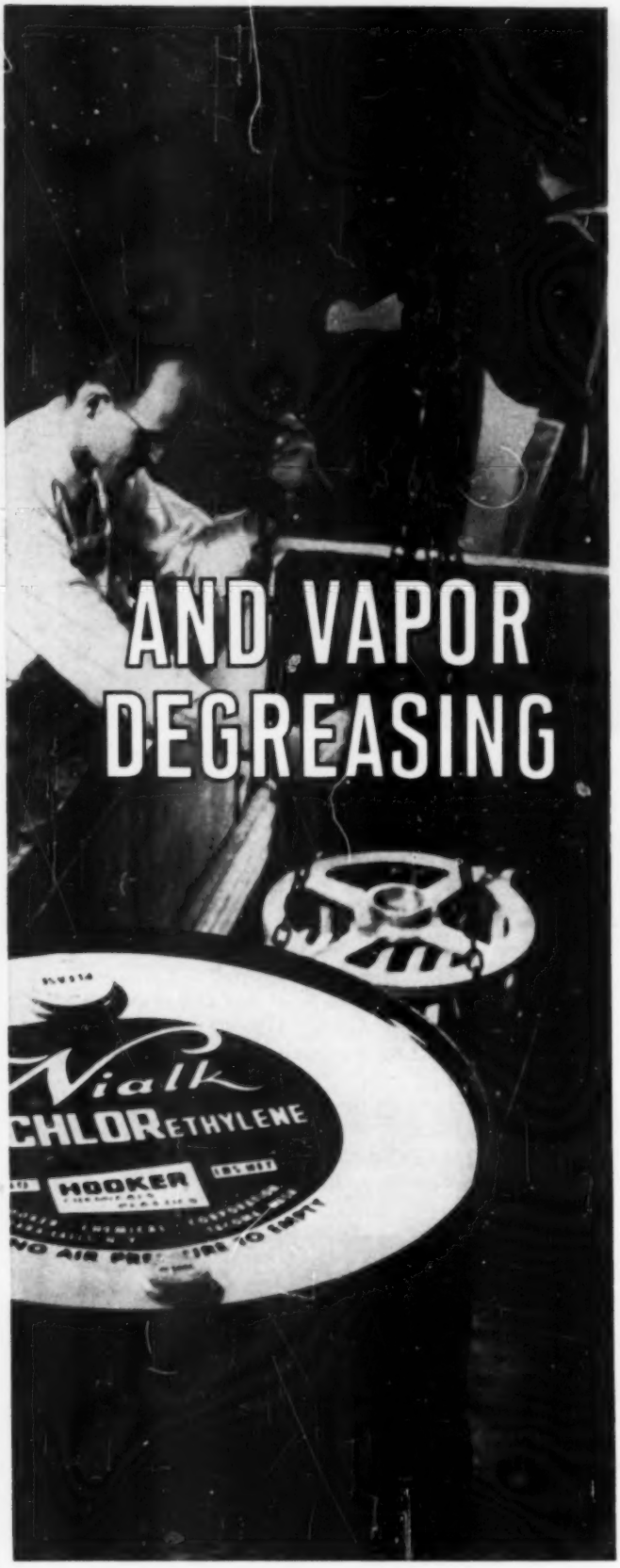

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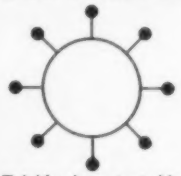
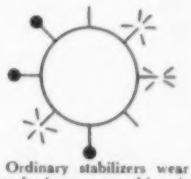
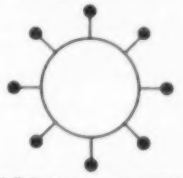


1. Trichlor is protected by stabilizer against heat, air, light, moisture, acids, and active metals.



2. Ordinary stabilizers wear out during use, making it necessary to titrate and add fresh stabilizer.

3. A sour solvent can even stain metals instead of cleaning them; affects bath operation, too.



Nialk has psp . . . permanent staying power. Always gives you full protection. Never goes sour.

HOOKER CHEMICAL CORPORATION

401 Union Street, Niagara Falls, N. Y.

HOOKER CHEMICALS PLASTICS

Sales Offices: Chicago, Ill.; Detroit, Mich.; Los Angeles, Calif.; New York, N. Y.; Niagara Falls, N. Y.; Philadelphia, Pa.; Tacoma, Wash.; Worcester, Mass.

In Canada: Hooker Chemicals Limited, North Vancouver, B. C.

Republic ELECTRUNITE Mechanical Tubing is used in four locations across the top of the automatic apparatus that picks up and sets the bowling pins in place. The AMF Automatic Pinspotter is manufactured by the American Machine & Foundry Company, Brooklyn, New York.

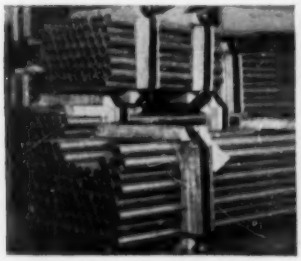
AMF . . . builds a better pinspotter for better bowling with Republic ELECTRUNITE Mechanical Tubing

On the initial order, Republic ELECTRUNITE® Mechanical Tubing saved American Machine & Foundry Company $34,000 in manufacturing their famous AMF Automatic Pinspotter.

AMF had been using tubing that required a boring operation on each end of the tube and centerless grinding on the O.D.

Because Republic's ELECTRUNITE Mechanical Tubing met AMF's O.D. tolerance requirements, the company was able to eliminate the boring and grinding operations. This resulted in a savings of $15,000 in fabricating operations. Another $19,000 was saved on the cost of ELECTRUNITE as compared with the tubing used previously.

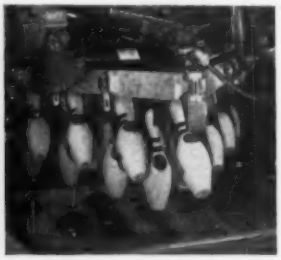
In uniformity and quality, in fabricating, in original costs, Republic's ELECTRUNITE Mechanical Tubing can save you time and money, too! Call your Republic representative, or write today.



Republic ELECTRUNITE Mechanical Tubing is delivered, cut to length, ready for fabricating. ELECTRUNITE Tubing is "electrically welded" resulting in built-in uniformity.

Slots to hold spotting cups in place are cut into ELECTRUNITE Tubing by machine. Concentricity of the ELECTRUNITE assures easy fabrication and smooth mechanical operation.

Drilling and cutting complete, the ELECTRUNITE Tubing is ready for assembly. Lightweight ELECTRUNITE offers uniform wall thickness, strength, ductility for greater serviceability.



Sensitivity in setting off-spot pins is the result of design and engineering, highest quality workmanship, and highest quality materials, such as Republic's ELECTRUNITE Tubing.

REPUBLIC NYLOK® FASTENERS SAFEGUARD PERFORMANCE SPECIFICATIONS. Republic fasteners are used extensively on Gemco Rotary, Reel, and Riding Power Lawn Mowers. Inset shows blade assembly securely locked to engine shaft with Nylok Cap Screw. An added advantage of Republic Nylok Bolts and Cap Screws is their ability to seal against fluid escape when wrenched tight. Nylon pellet in bolt body blocks flow of fluid along helical threaded path. Send for data.

REPUBLIC MANUFACTURERS' COARSE WIRE to meet every production need. Box Binding and Stapling, Brush Handle, Chain, Garment Hanger are only a few of the qualities regularly produced. Large tonnages are shipped to manufacturers of fan guards, wire partitions, concrete reinforcing specialties, plated shelves, racks and grilles, and numerous other products. Republic wire metallurgists are available to help you in solving production problems. Write today.

REPUBLIC HIGH STRENGTH STEEL IMPROVES SERVICE LIFE for many types of equipment. In the bottom of this conveyor, for example, it provides excellent resistance to abrasion and corrosion. Far less frequent replacement is required as compared with a bottom made of ordinary steel. And, its high strength-to-weight ratio allows use of lighter gages. Send for details.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. MP-6300
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send information on the following Republic products:

☐ REPUBLIC ELECTRUNITE Mechanical Tubing
☐ Republic Manufacturers' Wire ☐ High Strength Steel
☐ NYLOK Bolts and Cap Screws

Name_____ Title_____

Company_____

Address_____

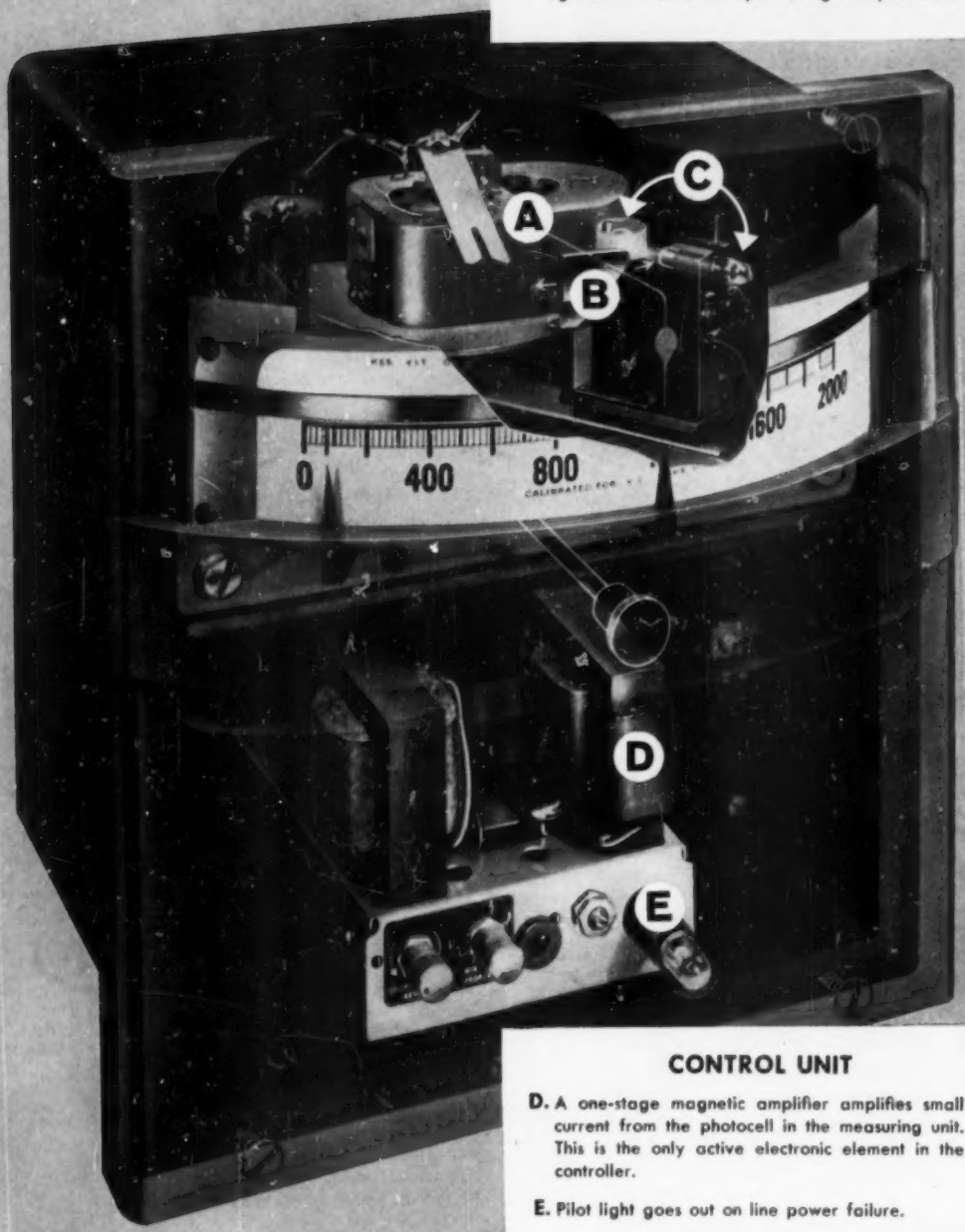
City_____ Zone____ State_____

MEASURING UNIT

A. A thermocouple signal to a d'Arsonval galvanometer, the only moving part, moves the indicating pointer up scale.

B. Aluminum vane adjusts the amount of light received by the photocell from the operating lamp.

C. If operating lamp or photocell fails, output voltage assumes a value equal to high temperature.

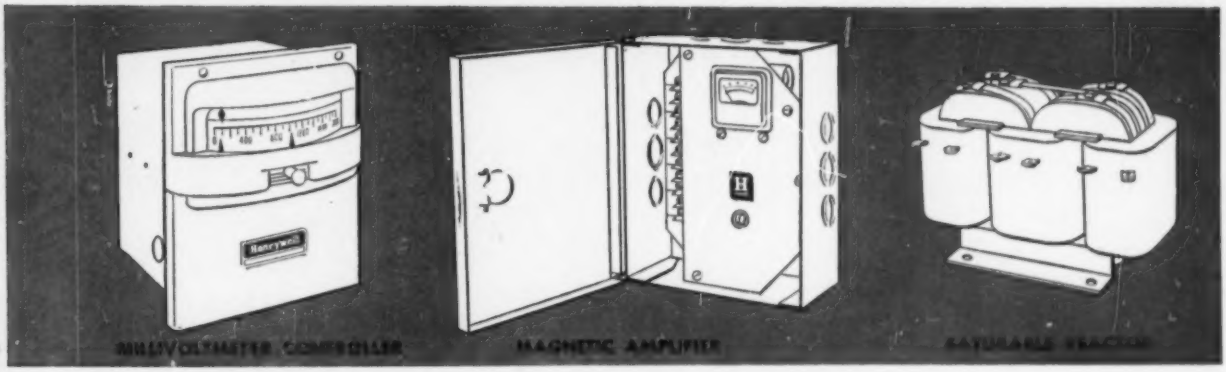


CONTROL UNIT

D. A one-stage magnetic amplifier amplifies small current from the photocell in the measuring unit. This is the only active electronic element in the controller.

E. Pilot light goes out on line power failure.

Pyr-O-Volt **controller is dependable and trouble-free. Built-in voltage regulator maintains voltage within ± 1% of level required for maximum operating stability. Thermocouple burnout protection is optional. Spare operating lamp is supplied with all instruments. Available in both horizontal and vertical case models.**



For your electric heating applications...

Use this accurate, dependable *Pyr-O-Volt** controller

- **No tubes to wear out**
- **Voltage regulation**
- **Fail-safe design**
- **Contactless, stepless control**

Here's an accurate instrument for reliable stepless control of saturable reactors, r.f. generators and other power amplifiers. It has a proportional band adjustable from ⅔% to 5%, and a manual reset adjustment which shifts the control point over 100% of the proportional band.

The *Pyr-O-Volt* controller can control saturable core reactors up to 100 kva, if used with a Brown magnetic amplifier. You can also use this proportional output millivoltmeter-controller with the General Electric *Reactrol***, and with the Westinghouse *Furnatron*.*** Complete packaged systems available.

Contact your nearby Honeywell field engineer for complete details. He's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

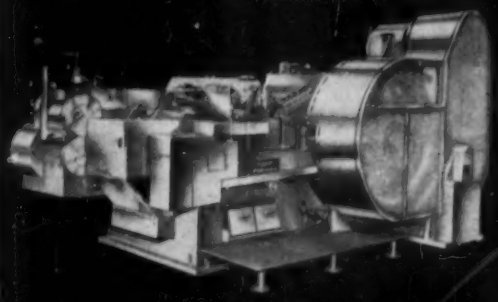
Honeywell

H HONEYWELL *First in Control*

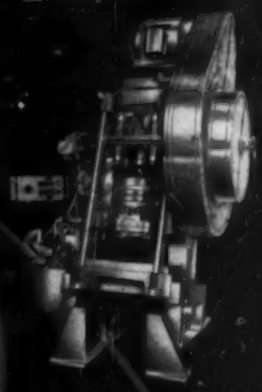
● **REFERENCE DATA: Specification S103-5**

*Tradename, Minneapolis-Honeywell Regulator Co.
**Tradename, General Electric Co.
***Tradename, Westinghouse Electric Corp.

COLD HEADING
MACHINERY



POWER
PRESSES



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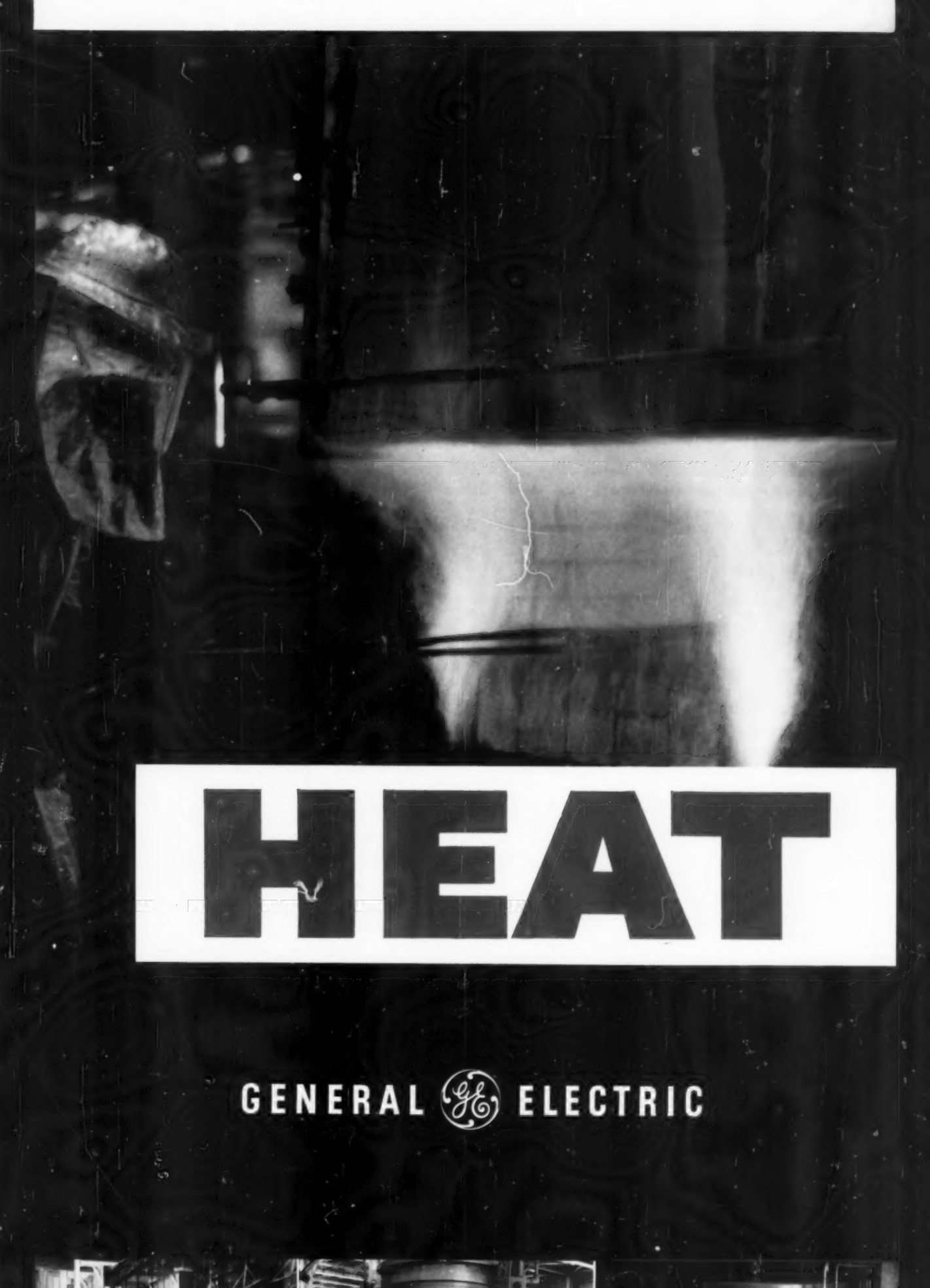
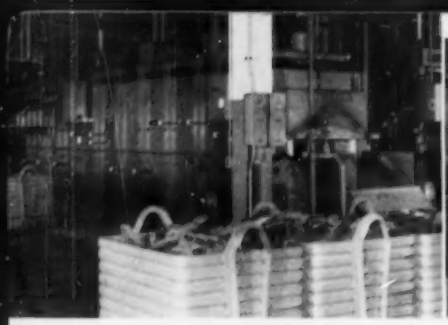
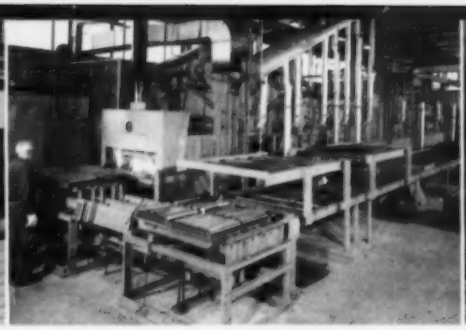
WF-54


HEAT
GENERAL ELECTRIC

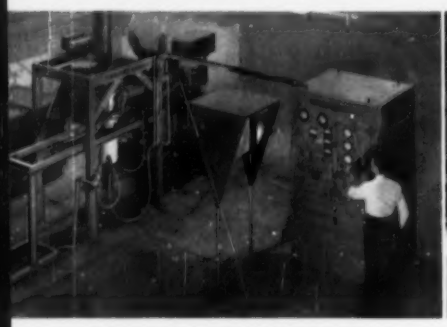


Conveyor Hardening Furnace

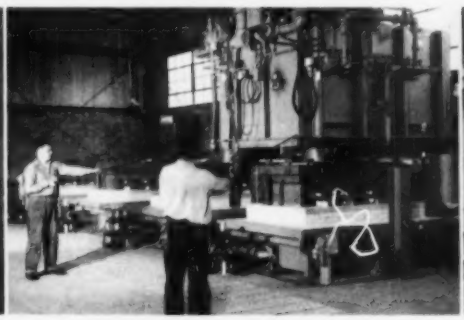


Gas-fired Roller Hearth Furnace

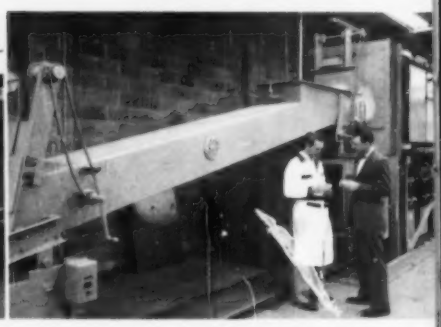
Car Bottom Furnace



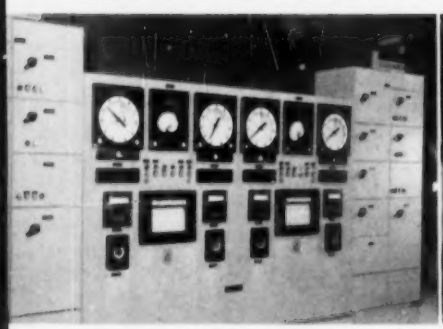
Vacuum Arc Melting Furnace



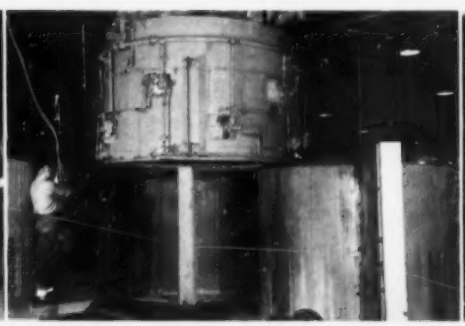
Gas-fired Vacuum Bell Furnace



Mesh-belt Furnace

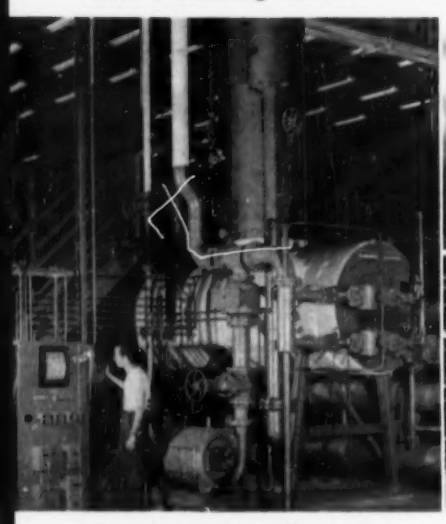


Heat Processing Control

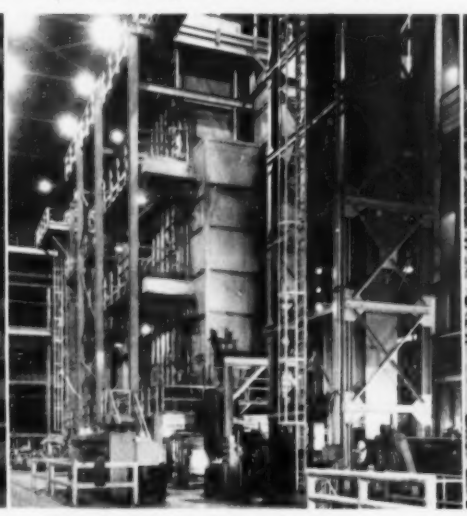


Gas-fired Cylindrical-bell Furnace

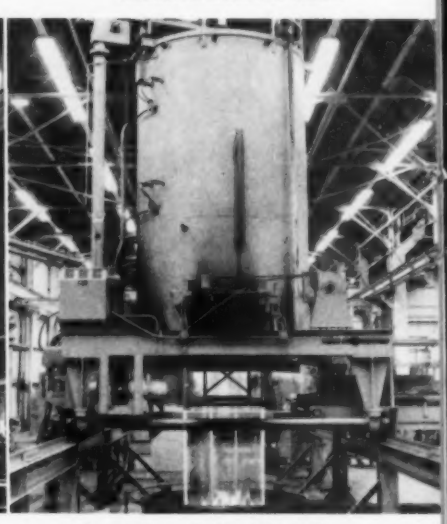
Electric Box Furnace



Gas Atmosphere Producer

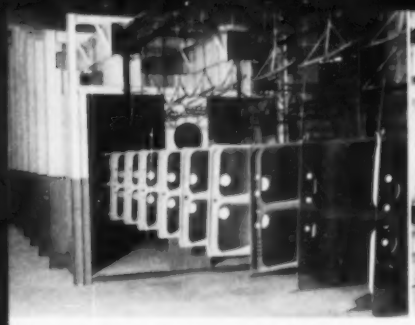


Vertical Strip Annealing Furnace

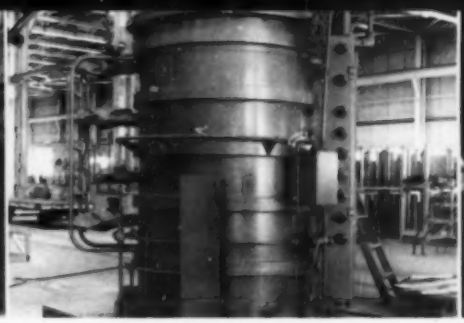


Traveling Cylindrical Furnace

GAS OR ELECTRIC HEAT FOR MANY



Overhead-conveyor Furnace



Double-pump Vacuum Furnace

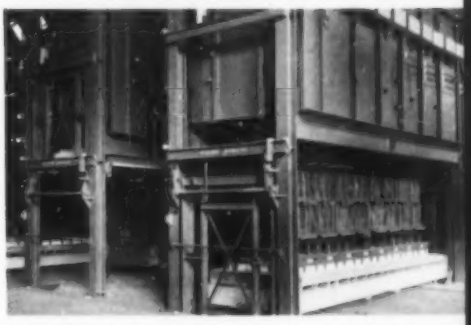
Rotary Hearth Furnace

SELECT YOUR APPLICATION...OR YOUR PROCESS

You'll find General Electric equipment designed for the job

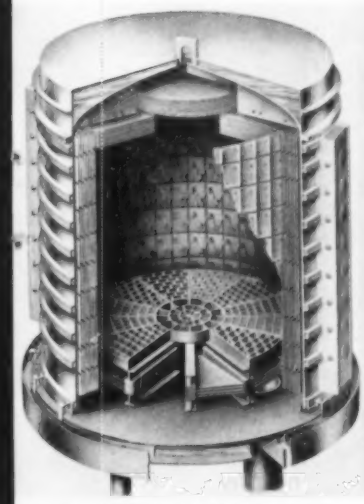
General Electric Heating Equipment for Your Process	Box with Cooling Chamber	High Temperature Box	Box with Retort	Mesh-Belt	Hump Mesh-Belt	Roller Hearth	Elevator	Low-temperature Bell	High-temperature Bell	Pit	Tower	Horiz. Ship	Rotary Hearth	Conveyor Hardening	Pusher	Car Bottom	Overhead Conveyor	Traveling Bell	Vacuum Bell	Wire Enameling	Purified Exothermic	Ammonia Dissociator	Endothermic	Exothermic	Vacuum Arc	Heaters & Devices
Aging							X	X		X																
Annealing	X	X	X	X	X	X	X	X	X	X	X	X			X	X		X	X		X	X	X	X		
Brazing	X		X	X	X	X	X		X						X	X			X		X	X	X	X		
Drawing	X			X		X		X		X			X		X	X		X			X			X		
Vitreous Enameling		X		X													X									
Continuous Wire Processing																				X	X	X	X	X		
Forging		X											X		X											
Malleabilizing						X	X	X	X						X						X					
Nitriding			X					X																		
Normalizing	X	X				X	X			X			X		X	X		X			X		X	X		
Hardening	X	X			X	X				X			X	X		X		X			X	X	X	X		
Sintering	X		X	X	X	X			X						X				X		X	X	X			
Stress Relieving	X		X	X	X	X	X	X					X		X	X		X			X			X		
Melting																									X	X

GENERAL ELECTRIC

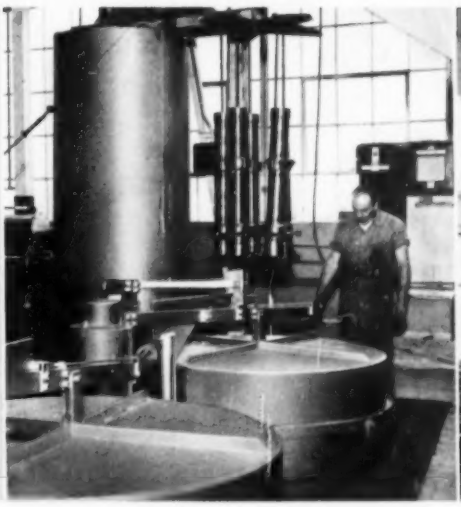


Elevator Furnace

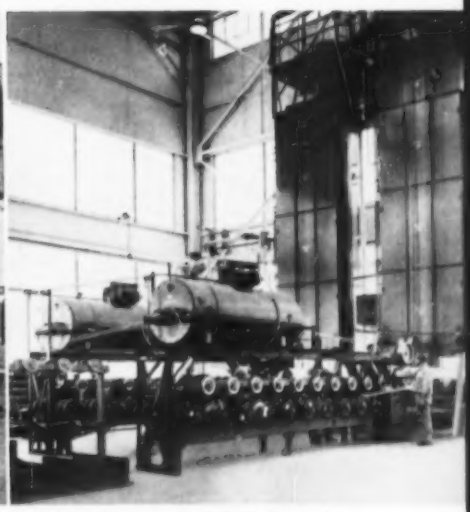
Pusher-type Furnace



Radiation Shield Furnace

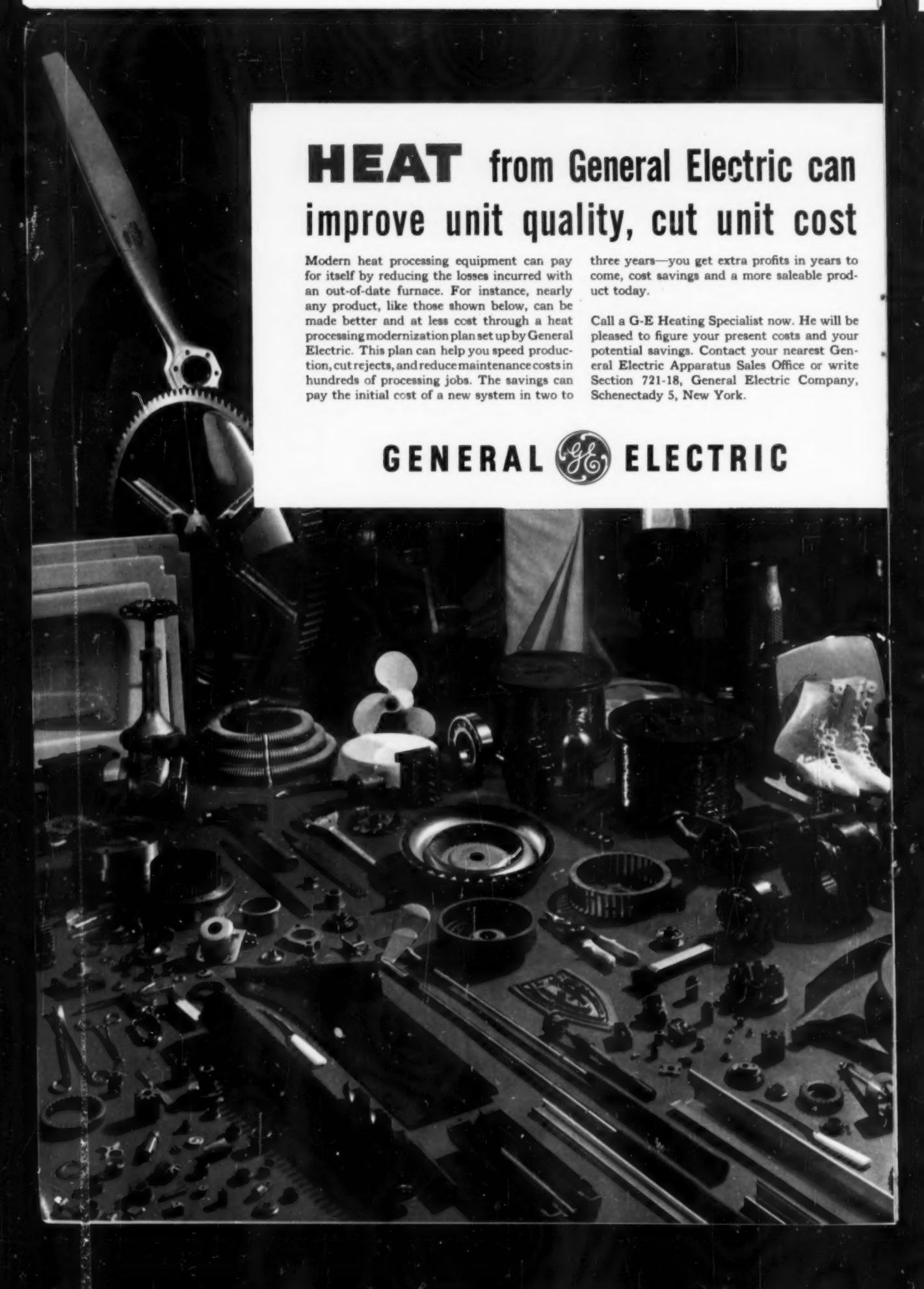


Cylindrical Pit Furnace



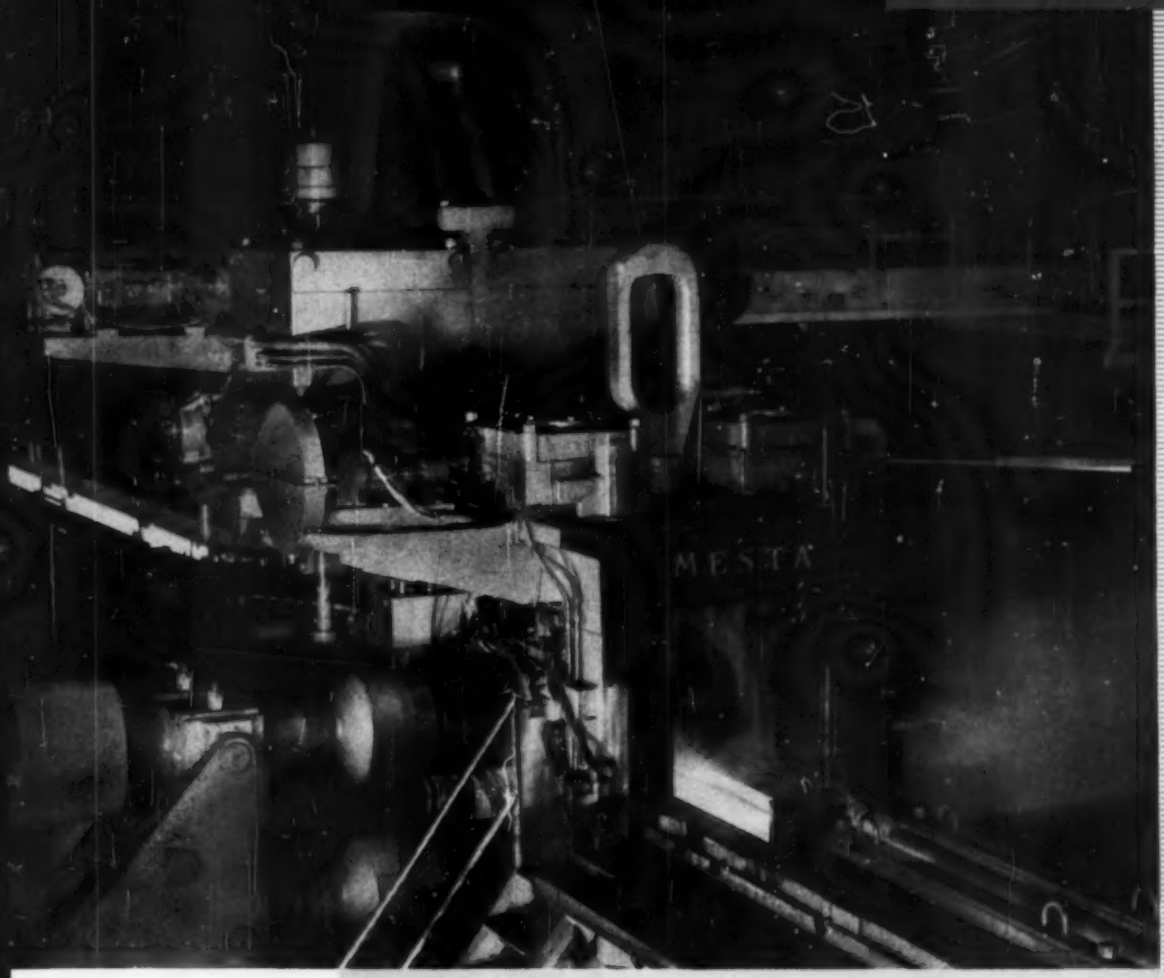
Wire Processing Equipment

APPLICATIONS....


HEAT from General Electric can
improve unit quality, cut unit cost
Modern heat processing equipment can pay for itself by reducing the losses incurred with an out-of-date furnace. For instance, nearly any product, like those shown below, can be made better and at less cost through a heat processing modernization plan set up by General Electric. This plan can help you speed production, cut rejects, and reduce maintenance costs in hundreds of processing jobs. The savings can pay the initial cost of a new system in two to three years—you get extra profits in years to come, cost savings and a more saleable product today.
Call a G-E Heating Specialist now. He will be pleased to figure your present costs and your potential savings. Contact your nearest General Electric Apparatus Sales Office or write Section 721-18, General Electric Company, Schenectady 5, New York.
GENERAL ELECTRIC

WIDE FLANGE BEAM AND STRUCTURAL MILLS

Designed and Built by MESTA



MESTA Universal Structural Mill rolling wide flange beams on the 44" Universal Stand and the 34" Edging Stand at Inland Steel Company, Indiana Harbor Works

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

MESTA
THERE IS NONE BETTER

A Complete Line of Lindberg

GTV-60 Vertical Tube Atmosphere Furnace: This furnace is ideal for numerous pilot plant or laboratory applications requiring protective atmosphere, cooling chamber and accurate stepless temperature control up to 2750° F.

Write for Bulletin T-1088

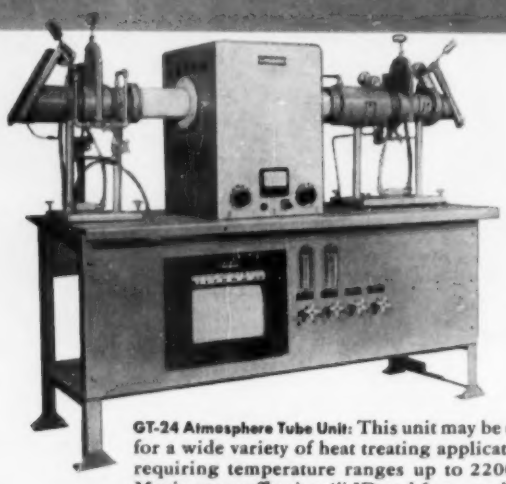
3 KW High Frequency Induction Unit: This unit has been designed for high frequency induction heating of both ferrous and non-ferrous materials, to any desired temperature up to 4200° F.

Write for Bulletin T-1093

Wherever heat is applied to industry there has long been need for economical experimentation beyond laboratory research and before actual production. Lindberg has now filled this need with this complete line of furnaces for pilot plant use. These furnaces provide, at moderate cost, means for developing techniques and methods for industrial heating applications under actual production standards ordinarily impossible to get with research laboratory equipment. Beyond this, they are generally usable for small

RB-45 Atmosphere Box Furnace: This rugged, compact furnace is designed for continuous operation at all heat levels up to 2000° F. It provides a clear working area 8" wide by 13" deep by 5" high.

Write for Bulletin T-1096

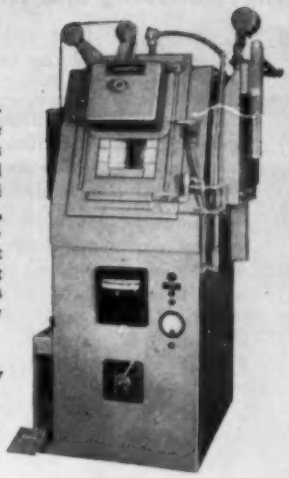


GT-24 Atmosphere Tube Unit: This unit may be used for a wide variety of heat treating applications requiring temperature ranges up to 2200° F. Maximum muffle size 4" ID and furnace chamber is 9" long.

Write for Bulletin T-1091

LINDBERG heat for industry

Furnaces for Pilot Plant Use



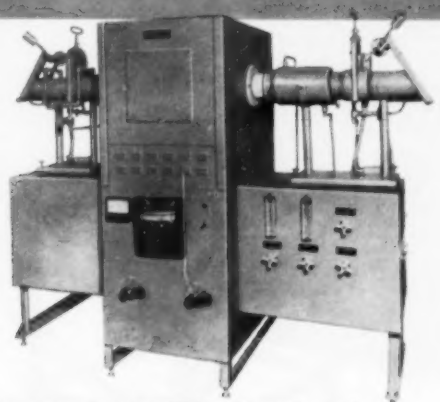
GB-30 Atmosphere Box Furnace: This general purpose heat treating furnace is designed for heavy and continuous duty at all heat levels up to 2500° F., but is capable of operation at 2700° F. for short or intermittent runs. It has a clear working area 6" wide by 12" deep by 5" high.

Write for Bulletin T-1087

RB-40 and RB-41 Box Furnaces: These non-atmosphere box furnaces provide precise temperature control up to 2000° F. Available in two chamber sizes: (RB-40) 4" by 4" by 10½", (RB-41) 5½" by 7½" by 14¼".

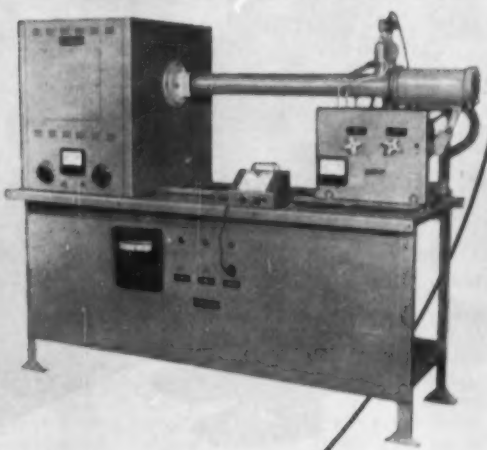
Write for Bulletin T-1086

production runs of small parts. Lindberg's long experience in the application of heat to industry has made possible the development of this useful pilot plant line. Lindberg's staff of engineers and technicians is also available to assist you in applying these furnaces, or any type of Lindberg equipment to your specific industrial heating problems. Consult your nearest Lindberg Field Representative (see your classified phone book) or write us direct for detailed information and descriptive bulletins.



GT-34 Atmosphere Tube Unit: This unit may be used for a wide variety of heat treating applications requiring temperature ranges up to 2750° F. Chamber 10" long, maximum tube size 4" ID. Available as floor or bench model.

Write for Bulletin T-1090



GT-25 Vacuum Retort Unit: This unit makes it possible to investigate vacuum metallurgy with a minimum investment. Provides temperatures up to 2150° F. with vacuum to 0.5 micron.

Write for Bulletin T-1085

Pilot Plant Equipment Division

LINDBERG ENGINEERING COMPANY 2448 West Hubbard Street, Chicago 12, Illinois

A Completely Self-Contained High-Frequency Induction Melting Unit That Can Be Installed In 2 Hours

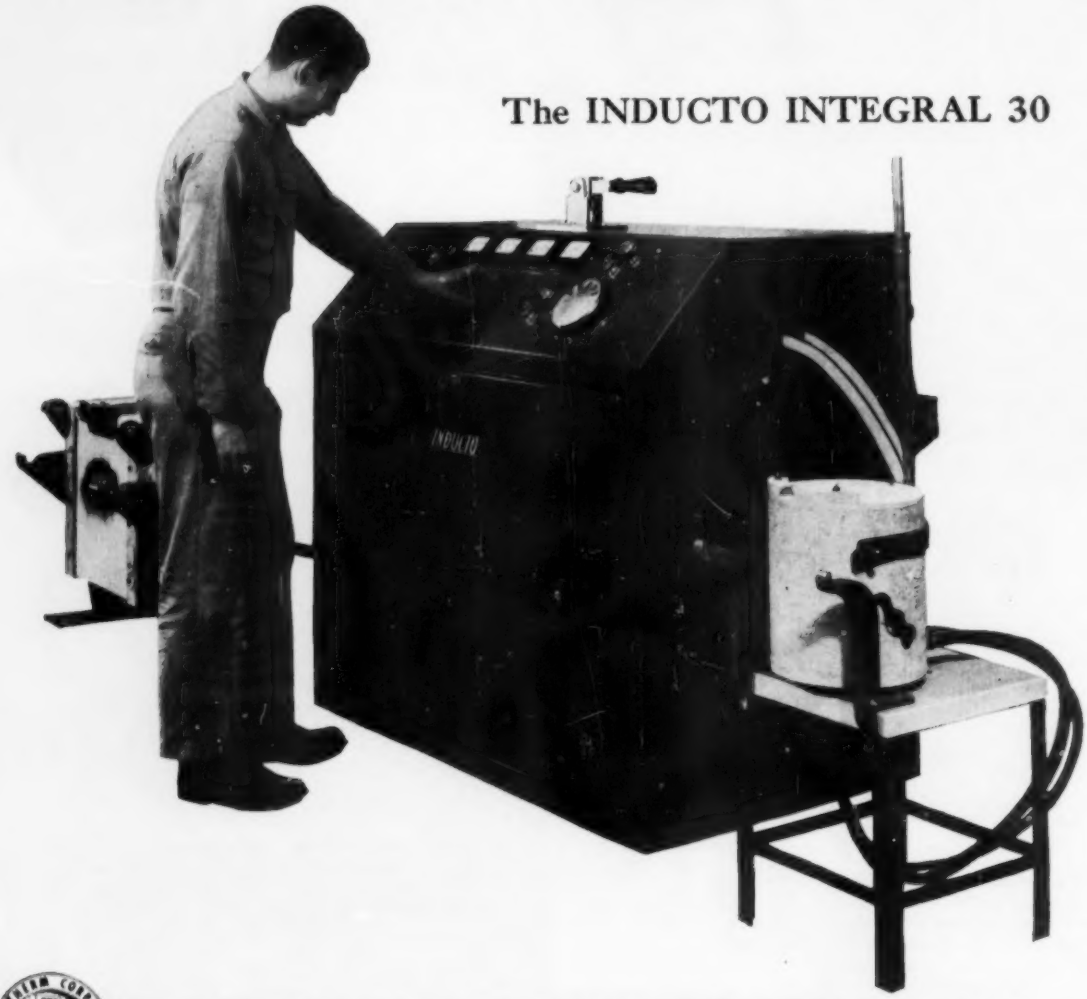
Ideal for Air or Vacuum Melting, Sintering and Hot Pressing

The Inducto Integral 30 is an efficient and economical melting unit that can be easily adapted to a variety of applications. Its console control panel contains all the equipment necessary to operate high-frequency induction furnaces and coils—a motor-generator set, capacitors, transformer and complete controls. Over 20 capacitor and 8 transformer steps, easily controlled from the front, provide the necessary flexibility to assure matching full power to all load conditions throughout the heating or melting cycles. The entire unit is designed for maximum dependability and ease of operation.

The Integral 30 is installed simply by connecting it to a 220 or 440 volt power supply, a cold water line and a drain. In fact, it is so compact and easy to install anywhere, the console can be made portable just by mounting it on casters.

Unique water-cooled leads simultaneously supply power and water to the furnaces. The same leads, with slight modifications, provide an economical power entry system for vacuum melting applications.

The Integral 30, with all the advantages of induction melting and Inducto engineering features, is truly the outstanding melting unit in the 5 to 100 pound range. No other equipment can offer you the same versatility, efficiency and economy. For complete details, write for Descriptive Bulletin 20-30, Inductotherm Corp., 412 Illinois Ave., Delanco, N. J.



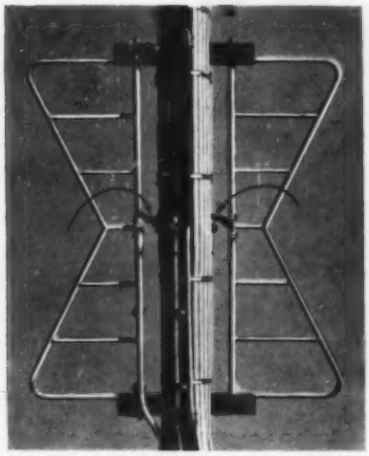
The INDUCTO INTEGRAL 30

INDUCTOTHERM

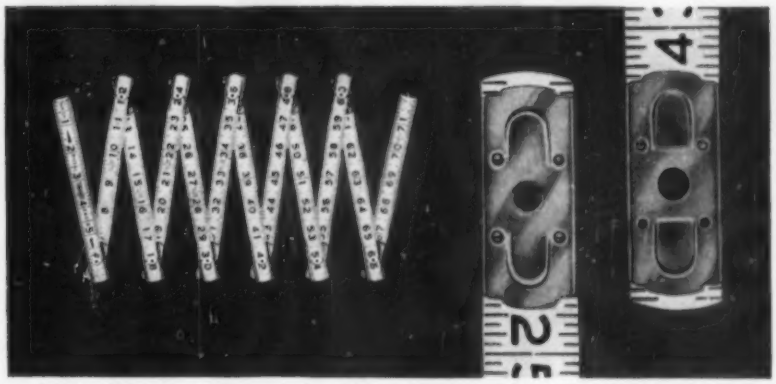
INDUCTO ... the mark of modern melting

TRY A FRESH APPROACH

Don't just take your metals for granted—specify the properties you need. The Man from Anaconda may come up with some very interesting answers.



Up where TV broadcast antennas stand, normal wind causes flexing of metals. So jumpers between coaxial cables and radiators must be resilient – beside being conductors, giving some structural support. Ordinary phosphor bronze seemed adequate, but there were fatigue failures.



To stimulate sales of its top-quality folding rule, and to meet Navy specifications, Eagle Rule Mfg. Corporation sought a metal for rule joints that would resist wear and corrosion, and provide the proper spring tension. Phosphor bronze, which had these qualities in excess of needs, cost too much.

American Brass suggested three alloys. Eagle Rule chose Ambronze-420 (88 Cu, 11 Zn, 1 Sn) because rule joints of this alloy met all requirements, withstood 400,000 cycles in wear test (Navy required 7000). It cost only pennies per pound more than yellow brass, much less than phosphor bronze.

RCA listed desirable properties of phosphor bronze – added *extra*-high endurance, *extra*-long fatigue life. American Brass suggested Duraflex®, Anaconda superfine-grain phosphor bronze. RCA tried it, found it the answer—at no extra cost—specified Duraflex to the manufacturer, Dielectric Products Engineering Co., Inc., Raymond, Maine.

Technical Oil Tool Corp. asked Anaconda to help select the metal for a new magazine-type clip used to close surgical incisions. The metal had to provide the right tension to hold edges together, yet open easily–form readily, hold sharp die-cut edges, be proved in surgical use.

American Brass technical specialists suggested Nickel Silver, 18%-719 as best suited to meet all requirements. Autoclip, shown in use above, is the result. Incisions are held together with least damage to tissues. Surgeons can work faster in applying and removing clips.

STARTING with 93 standard alloys, The American Brass Company can make minor variations in composition, fabrication, and annealing to provide an almost unlimited number of combinations of useful properties. When new or unusual problems arise, ask for the help of the Technical Dept. in selecting the right metal. For such help or a copy of Publication B-32, "Anaconda Copper & Copper Alloys," write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario, Canada.

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MILL PRODUCTS

Made by The American Brass Company

TESTING AT

3500°F

AND ONLY

"LUKEWARM"

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HYDRAULIC FATIGUE TESTING MACHINES

HYDRAULIC UNIVERSAL TESTING MACHINES

UNIVERSAL SCREW POWER TESTING MACHINES

As elevated temperature ranges continue to climb, needs are created for complete systems of equipment capable of testing physical properties of materials at high temperatures.

NOW — from *one* source, ready-to-operate systems incorporate all of these components:

1. **BASIC TESTING MACHINE**
2. **STRAIN MEASURING INSTRUMENTATION** for atmosphere, controlled atmosphere and vacuum furnaces
3. **COMPLETE HIGH TEMPERATURE ACCESSORIES** including furnaces, temperature controllers, vacuum pumps and complete related instrumentation.

With testing temperatures up to 3500°F currently available, Riehle engineers expect to announce a new range up to 4000°F in the near future.

For saving time on vital projects, rely on RIEHLE. Contact us regarding your requirements for physical testing at elevated temperatures.

Riehle TESTING MACHINES

A DIVISION OF

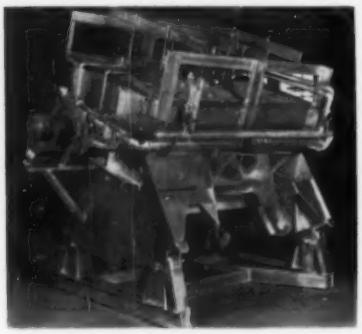
American Machine and Metals, Inc.

DEPT. MP-159, EAST MOLINE, ILLINOIS

APPLICATION and EQUIPMENT new products

Aluminum Melting

A new line of radiant-fired, tilting, reverberatory furnaces for aluminum melting has been announced by the J. A. Kozma Co. The furnace rides on bearing-mounted rails and tilts through a 20° arc for pouring. Tilting action is accomplished by means

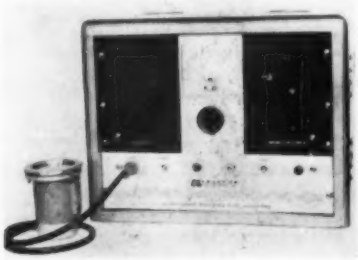


of a push-button controlled pneumatic cylinder. The ladle is hung from integral ladle arms and may be removed and transported by a revolving-head lift truck. A charging well, rather than a door, facilitates the removal of iron or steel inserts in scrap die castings. Melting capacities are from 500 to 2000 lb. per hr.

For further information circle No. 1 on literature request card, page 48-B.

Ultrasonic Cleaner

Acoustica Associates, Inc., has announced a new ultrasonic cleaning system. The new DR-500-AL ultrasonic cleaning system operates on 500 watts. This higher power and increased transducer efficiency over the earlier model have doubled cleaning



effectiveness. Tank sizes range from ½ to 2 gal.

For further information circle No. 2 on literature request card, page 48-B.

Conveyor Belts

Ashworth Bros., Inc., has announced a heavy-duty version of their standard-weight Omniflex belt. These belts have a turning radius 2 times the belt width, open mesh, flat surface and positive drive. Omniflex is designed to produce a flow conveyor around corners, structural obstructions, other machines and to eliminate dead plate transfer or transfer belts.

For further information circle No. 3 on literature request card, page 48-B.

Spectrograph

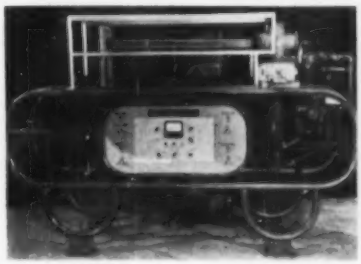
A new 100 kilovolt X-ray spectrograph has been announced by the Instruments Div., Philips Electronics, Inc. The new instrument covers a range of 87 elements in the atomic

scale extending from magnesium (No. 12) to californium (No. 98). Specimens are exposed to an intense beam of X-rays which causes the elements to give off secondary radiations. These rays pass through a collimating system to a crystal which serves as an analyzer. The crystal reflects the radiation from each element at a specific angle. Intensities are measured by scintillation or proportional counters. Cooling water to the 100 kv. spectrograph must be supplied at a rate of 3½ qt. per min. at 30 psi. at room temperature. Power requirements are 200 volts, 60 cycles, single phase, 25 amp.

For further information circle No. 4 on literature request card, page 48-B.

Zone Melting

The Instruments for Industry Div. of Materials Research Corp. has announced an integrated zone melting apparatus which can be operated either vertically or horizontally to do zone refining, zone leveling and crys-



tal pulling. The high-vacuum unit and the zone melting apparatus are integrated into one unit. The number of passes is automatically controlled. Melting zone is ⅛ in. deep. New design of the charge tube permits operation between −45 to +45° tilt.

For further information circle No. 5 on literature request card, page 48-B.

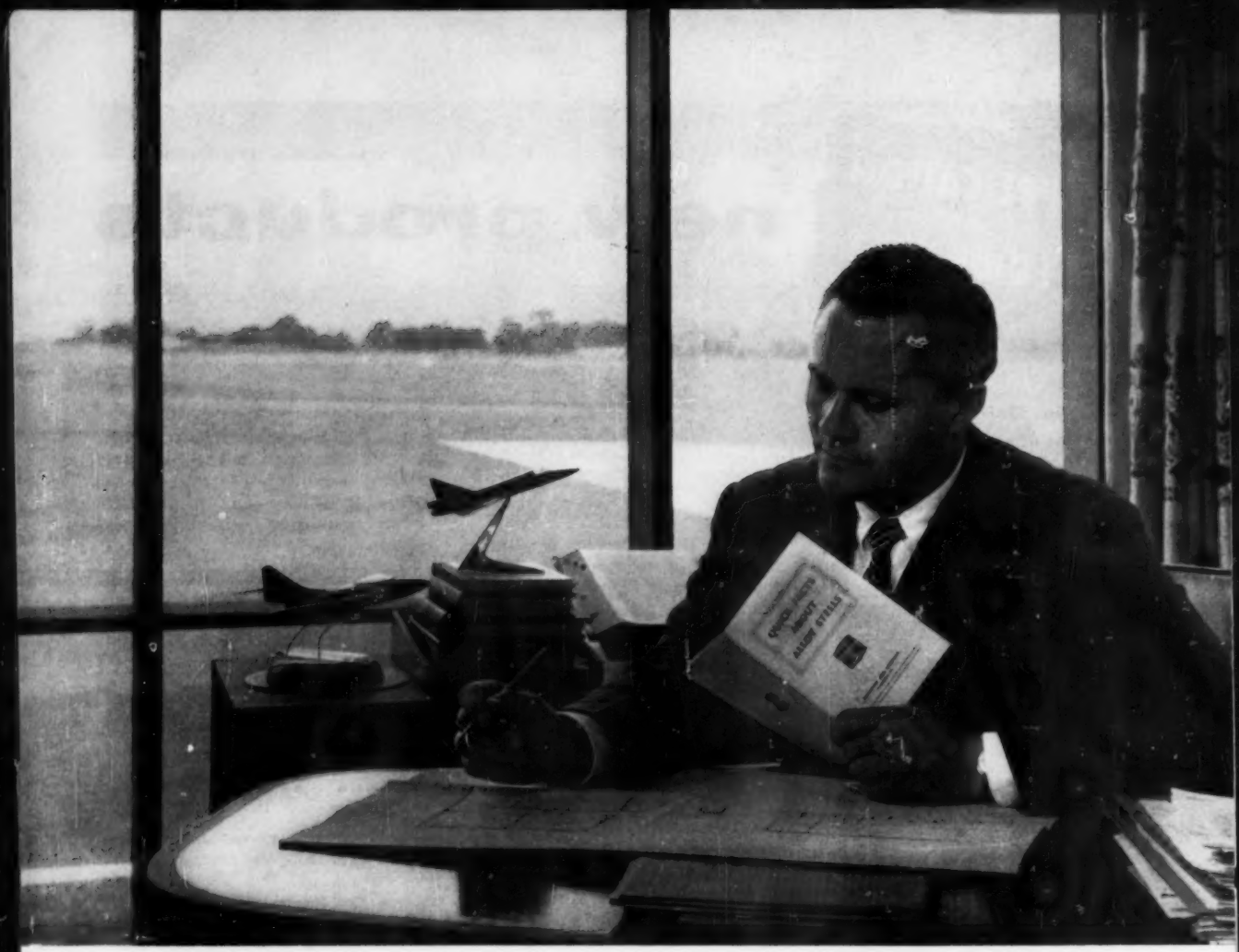
Microhardness Tester

A microhardness tester that permits direct readings corresponding to Vickers 100 to 1000 within 15 sec. has been announced by Newage Industries, Inc. It measures resistance hydrostatically. Small wire, tips of cutting tools, surgical needles, wire punches, surface layers, thin sheet stock and flat springs can be checked. Slight vibrations do not affect the tester. The microhardness tester can be obtained in 1 or 2 kg. loads penetrating as little as 0.000079 or 0.00016 in., respectively.

For further information circle No. 6 on literature request card, page 48-B.

Burner

A new burner that distributes heat at right angles to burner centerline has been announced by North American Mfg. Co. Local hot spots in front of the burner have been eliminated by producing a flame without forward velocity. The flame heats a large area of the furnace wall behind the burner



The little booklet on alloy steels that grew into a textbook . . .

Quick Facts about Alloy Steels appeared for the first time in 1956, as a collection of reprints of a series of Bethlehem advertisements in metalworking magazines.

The small booklet was well received, and we kept adding more of the informative advertisements as we reprinted it to keep up with demand. Today, it has grown to 40-page size, and is in its Third Edition. More than 20,000 booklets have been distributed at the written request of executives, engineers, designers, and others, who have found *Quick Facts* to be an authoritative small textbook on the fundamentals of alloy steels. Here's what a U. S. Navy engineer wrote:

"*Quick Facts* is a small textbook of information—a booklet that has been needed for a long time. One of my associates and I had a metallurgical problem involving alloy steels. We just didn't have the information. A friend showed me a copy of your booklet *Quick Facts,* and there on one page, under the subject 'Determining Depth Hardness,' was just what we wanted to know!"

The current booklet contains reprints of the complete series of advertisements, on such subjects as, "What is an Alloy Steel?" "Effects of Elements," "Grain Size," "Heat-treatment," "Quenching Media," and others. It's written in concise, layman's language, from data compiled by Bethlehem's metallurgical engineers.

Would you like a copy of the *Quick Facts* booklet? Just fill out and send in the coupon.

PUBLICATIONS DEPARTMENT, ROOM 1030
BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

Please send me your "Quick Facts about Alloy Steels" booklet.

*NAME*_____

*COMPANY*_____

*ADDRESS*_____

*CITY*_____ *STATE*_____

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

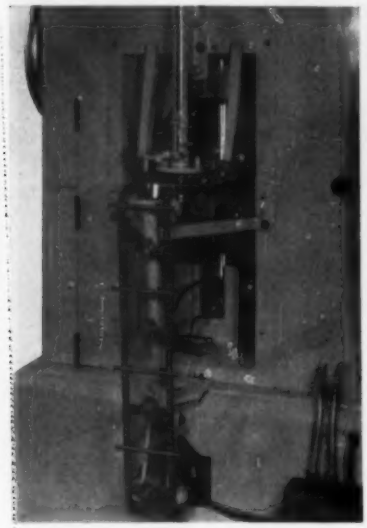
BETHLEHEM STEEL

without the aid of impingement baffles or any other heat distribution device. The Flat Flame is a nozzle-mix gas burner offered in six sizes with air connection ranging from 1¼ to 4-in. pipe size. Burners operate on 12 to 16 ounces per square inch air pressure at high fire, with capacities of 234,000 to 2,620,000 Btu. per hr. at 16 ounces per square inch.

For further information circle No. 7 on literature request card, page 48-B.

Presses

A series of mechanical presses with a feeding mechanism which permits automatic operation and quick setup for secondary operations such as assembling two or more parts together, marking, staking, crimping and sizing



has been announced by Haller, Inc. With a chain feed, parts can be automatically dropped into the carriers where they are then transported forward to the die opening. After the operation, an ejection movement in the press places the completed parts back in the carrier where they are then ejected down a chute in the front of the machine. Presses are available in capacities of from 18 to 75 tons.

For further information circle No. 8 on literature request card, page 48-B.

Magnesium Sheet Alloy

A new magnesium sheet and plate alloy that does not require stress relief after welding has been announced by the Dow Chemical Co. Alloy ZE10A contains zinc and rare earth metal as alloying constituents. Applications suggested are missile shipping and storage containers, shipping containers for commercial bulk products, and tank-trailer bodies. The alloy has good toughness. Typical mechanical properties for ZE10A in the H24 temper (strain hardened, then partially annealed) include: tensile strength, 38,000 psi; tensile yield strength, 28,000 psi; compressive yield strength, 26,000 psi. The alloy also is furnished fully annealed.

For further information circle No. 9 on literature request card, page 48-B.

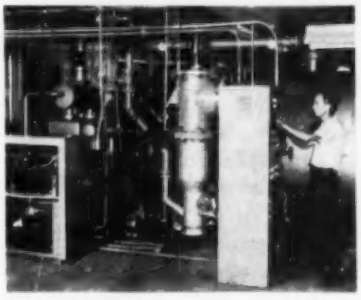
Thickness Control

A new method of automatically controlling the thickness of steel strip and plate has been announced by General Electric's Industry Control Dept. Using the mill itself as a "flying micrometer," the gage meter system calculates metal thickness, and automatically adjusts roll opening or interstand tension to provide a uniform finished product. The control can be applied to both new and existing mills. The system is based on the fact that roll separation is equal to the output of the strip thickness. Roll separation is computed on the basis of the unloaded roll opening plus the added roll opening caused by deformation on the rolls and springs in the mill housing with metal in the mill. Because the system is subjected to slowly drifting errors caused by roll wear and roll expansion due to thermal changes, a compensating X-ray gage is needed to reset the references on the gage meter system.

For further information circle No. 10 on literature request card, page 48-B.

Vacuum Metallizing

A two-stage refrigerator to keep a large load at −150° F. is being used in vacuum metallizing according to Harris Refrigeration Co. The unit provides a special cold trap which reduces humidity and speeds up



metallizing. The traps freeze out the water vapor before it loads up the diffusion pumps. The mechanically refrigerated cold trap is shown on the left in the picture above.

For further information circle No. 11 on literature request card, page 48-B.

Stripping Compound

Oakite Products, Inc., has announced a compound for stripping epoxy resins, acrylics, vinyls, poly-

Looking for

HARDNESS TESTING FACTS?

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Catalog contains complete details on all types of Brinell Hardness Testers . . . for laboratory, or production: Dead Weight, Hydraulic, Hand or Motor Operated, Large or Small, Standard and Special.

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UNILOY
STAINLESS STEELS

The gleaming beauty, plus the permanence and ease of cleaning have made stainless steel the wife's delight—and sold many a home.

When made from Uniloy stainless steel, flatware, utensils, and other kitchen accessories have that inviting blend of beauty and permanence so appealing to the modern homemaker.

Uniloy stainless steels—easy to work and form—are rolled to most exacting specifications by steel makers who have been making specialty steels since 1884.

UNIVERSAL CYCLOPS
STEEL CORPORATION
BRIDGEVILLE, PA.

STAINLESS STEELS • TOOL STEELS • HIGH TEMPERATURE METALS

esters, and other hard-to-remove finishes. It combines solvent and acid properties with a built-in water seal and is used full strength, at room temperature. Parts are stripped by immersion.

For further information circle No. 12 on literature request card, page 48-B.

Rolling Mills

The Fenn Mfg. Co. has announced tnat one four-stand and two two-stand tandem rolling mills will be used in the production of nuclear fuel elements. The four-stand, two-high mill has 12-in. diam. rolls; the two-stand mills are four-high with 3¼-in. diam. work rolls and 12-in. diam. back-

up rolls, work-roll driven. All three mills have integral material handling equipment which automatically conveys fuel element plates between each stand. Stands have separate d.c. drive, high-powered dual motor screwdowns and are equipped with automatic lubricating and roll cooling systems.

For further information circle No. 13 on literature request card, page 48-B.

Vacuum Gage Control

A new high-vacuum gage control, which covers the range from 1 to 1 x 10^{-8} mm. Hg, has been announced by NRC Equipment Corp. The control provides readings from one ionization

and two thermocouple gages. A protective relay, which operates when the pressure increases to 1½ to 2 times the scale to which the control is set, guards the ionization gage against burn-out due to pressure surges. The protective relay also activates a 5-amp., 110-volt relay which can be used to operate alarm or control devices. An ionization emission current stabilized at 1, 5 or 10 milliamperes may be selected. This is convenient for leak hunting.

For further information circle No. 14 on literature request card, page 48-B.

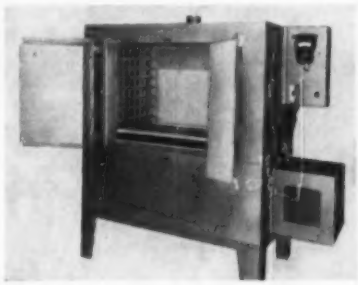
Explosive Forming

Chromalloy Corp. has announced a system by which 11-ft. rocket booster cases are being produced by explosive metal forming. It involves the use of an explosive charge, a shock transmitting medium, and the object to be formed all contained within a constraining die. The force of the explosion contained within the unit distributes the metal as desired. A steel cylinder weighing 14,000 lb. was constructed. Within this cylinder a Propellex solid fuel of high detonation velocity was used to complete the forming of the rocket cylindrical case. The strength of the metal being formed is increased by 30%. This method can be used to form refractory metals such as chromium, molybdenum and titanium.

For further information circle No. 15 on literature request card, page 48-B.

Ovens

The L & L Mfg. Co. has announced a new line of Cyclo-Flow cabinet ovens. Designed for laboratory and



production, these ovens are made in 500, 650, 850 and 1000° F. ranges. They are equipped with heating chamber air velocity control of from 200 to 600 ft. per min., indicating temperature controller, low watt density elements and other standard features.

For further information circle No. 16 on literature request card, page 48-B.

Air-Gas Mixer

To maintain heat processing operations during periods of fuel cutoff, Selas Corp. of America has announced a propane diluter which automatically supplies mixtures of propane and air, or butane and air. It is available for small, medium and large installations, and can be connected to existing gas piping. The diluter has a balanced pressure, full-floating mixing valve with gas and

WORD FROM Waukee...

ETT GOTT NYTT ÅR

32 industrial furnace builders in the U. S. use Waukee equipment. More often than not when a furnace company buys Mixors or Flo-Meters, we ship direct to them and they, in turn, install it on their equipment and ship to their customer. We do not know who the ultimate customer is until perhaps we receive correspondence from him.

Just recently we were greeted by a letter from Per Blomberg, Supt. of Heat Treating at VOLVO-KÖPINGVERKEN AB, Koping, Sweden. Mr. Blomberg inquired for prices and specifications of spare parts for some Waukee equipment in his shop. We airmailed a reply and an order came back in a few days. If memory serves, this was our first order direct from Sweden. It caused us to reflect on how far this little candle throws his beams. So we dug out records and found that we had shipped to India, Japan, Australia, Switzerland, Belgium, Germany (West), France and England.

To what other countries our products have gone, we know not, but it is appropriate that at this turn of the year we say to Mr. Blomberg in Koping and readers of Metal Progress in places far from Milwaukee, "God rest you merry gentlemen — may nothing we do dismay you."

To our friends of the 32 U. S. furnace companies, our sincere gratitude for your many kindnesses during the past year and our deep appreciation for your patience with us when we may have performed with something less than perfection.

AND FLO-METER CAPACITY TABLES:

We wrote last month about how useful our Bulletin 204 on Waukee Flo-Meters is and we showed the front cover. For this we have been taken to task — as a good friend pointed out the cover is the least useful part of the bulletin. So here's what the capacity tables look like — and they are the heart and soul of the bulletin. You may have a copy along with price list by addressing us at 5140 North 35th Street, Milwaukee 9, Wis. R.C.O.

Waukee FLO-METERS
GAS-AIR MIXORS
ROTARY-VANE COMPRESSORS
INDUSTRIAL WASHING MACHINES

ACHESON

dispersions digest

Reporting uses for

dag® BRAND DISPERSIONS

COLLOIDAL GRAPHITE, MOLY-SULFIDE, VERMICULITE, AND OTHER SOLIDS

SUPERIOR CASTINGS, LONGER DIE LIFE ATTRIBUTED TO 'DAG' DISPERSIONS

Die casters and molders are expressing a growing preference for Acheson 'dag' brand colloidal dispersions. The consistent high quality of these products and the multiple benefits they offer have obsoleted most other mold cavity coatings. As outlined below, Acheson dispersions greatly aid in the manufacture of more uniformly sound castings having smoother surface finishes, facilitate metal flow and parting, and consequently extend the effective service lives of the dies and molds on which they are used.

Acheson 'Prodag'®, spray-applied on permanent molds at Paragon Aluminum Corporation, has given them consistently higher quality castings and fewer rejects.

Better surface finish with 'Prodag' permanent mold coating is just one of the reasons why Paragon Aluminum Corporation, a Division of Detroit Harvester Company located at Monroe, Michigan, switched to this Acheson product. After four years of experimentation with other mold washes, Paragon chose 'Prodag' — Acheson semi-colloidal graphite in water — and has used it constantly the past seven years. The reasons for its choice are these; uniform consistency, excellent heat-transfer quality, and its hard, smooth, tenacious film which resists flaking and provides easier parting characteristics.

With about 95 per cent of its annual output of more than two million pounds of castings going to the automotive industry, Paragon must insist upon quality. 'Prodag' helps to maintain this standard. These parts for convertible automobile tops are precision-molded from both 355 and 319 aluminum alloy. Molds are preheated before each day's run to 600°F and the casting cycle maintains this temperature. The 'Prodag' dilution ratio is 1 to 4 parts water and is applied to the molds with a commercial spray gun. Aside from occasional touchup at points of greatest wear, this coating lasts through the entire run. Because of the physical contours involved in these comparatively small, light castings, they require rapid cooling in certain areas to insure uniform strength. The 'Prodag' coating — with its proven fast heat transfer ability — allows the castings to cool without breaks or pinholes. And by parting more easily, the high-finish castings which result have given Paragon Aluminum products wide acceptance in this demanding industry.

Typical parts cast at Paragon Aluminum include these automobile convertible top braces. More uniform strength, better finish, and fewer rejects result from this company's use of Acheson 'Prodag'.

If you have a metal casting problem, call in your Acheson Service Engineer. Or if you prefer, write direct for additional information contained in our Bulletin No. 425. Address Dept. MP-1.

'dag' and 'Prodag' are trademarks registered in the U.S. Patent Office by Acheson Industries, Inc.

Colloidal graphite increases die life because of its stability at high temperatures, excellent lubricating qualities, and its ability to prevent adhesion and the scrubbing effect of hot metal. This cannot be said of conventional petroleum compounds which either decompose rapidly at temperatures above 300°F or do not possess the required lubricity necessary under good die casting procedures. It will not volatilize when in contact with the hot metal and cause pock marks due to gas formation. It will perform when present in extremely thin films which will not affect dimensions or cause discoloration of the parts being cast. And since it does not volatilize or otherwise be destroyed in the casting process, it does not need to be applied as often as other lubricants. This fact alone has often increased production as much as 25%. Investigate the use of an Acheson colloidal dispersion in solving your die casting problem . . . *It probably is the very answer you need.*

ACHESON *Colloids Company*

PORT HURON, MICHIGAN

A division of Acheson Industries, Inc.

Also Acheson Industries (Europe) Ltd. and affiliates, London, England

Offices In: Boston • Chicago • Cleveland • Dayton • Detroit • Los Angeles • Milwaukee New York • Philadelphia • Pittsburgh • Rochester • St. Louis • Toronto

air metering ports. The valve is adjusted through a vernier-type worm-wheel mechanism for control of gas-to-air ratio and is capable of turn-down through a range of 50 to 1.

For further information circle No. 17 on literature request card, page 48-B.

Phosphate Coating

Klem Chemicals, Inc., has announced a new iron phosphate coating compound used at temperatures from 70 to 120° F. Coating weights up to 150 mg. per sq. ft. are attained, depending on type of metal and concentration. Coatings are applied by two-stage or multiple-stage systems.

For further information circle No. 18 on literature request card, page 48-B.

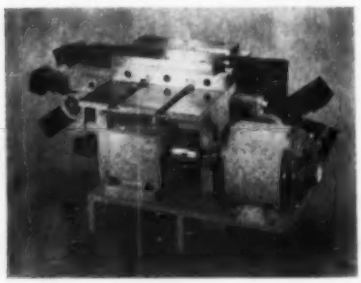
Torsion Testing

A remote control torsion testing machine has been announced by the Tinius Olsen Testing Machine Co. The only connection between the loading and indicating units is electrical wiring. With this new machine torque is applied and indicated in both directions of rotation by means of an electromechanical loading system. A light in the control panel shows the direction of loading.

For further information circle No. 19 on literature request card, page 48-B.

Milling

Sieburg Industries, Inc., has announced an automatic milled parts unit for holding parts to be milled at speeds of 1500 to 3000 parts per hour. The unit is powered by a motor and gear reducer, driving a matched set of 24 clamping jaws beneath the milling cutter. Parts are hand inserted or hopper fed into the clamping jaws; the continuous milling fixture clamps and carries the parts beneath the milling cutter; the parts are milled and the clamping pressure is released; the parts are ejected from the jaws and the cycle is repeated.



For further information circle No. 20 on literature request card, page 48-B.

Tube Furnaces

The Laboratory Equipment Div. of Lindberg Engineering Co. has announced improved and redesigned combustion tube furnaces for carbon and sulfur analysis of ferrous and nonferrous samples. They operate at

temperatures up to 2650° F. The furnaces are available in one and two-tube models and are adaptable to 1, 1¼ and 1½ in. combustion tubes.

For further information circle No. 21 on literature request card, page 48-B.

Resistance Heaters Correction

Misunderstandings have arisen concerning new product item 662 in the October 1958 issue on a new line of electric resistance heaters. These electric resistance heaters are made and sold by the Herscott Co. of Rockford, Illinois. The units are equipped with Wheelco instruments.

Inspection

A new ultrasonic Reflectoscope for both contact and immersion testing has been announced by Sperry Products, Inc. It weighs 75 lb. and is equipped with skids. The UR-600 has new pulser and receiver circuitry, a variable pulse repetition rate and a bright video display. A selector switch accommodates short-cable, long-cable and through-transmission operation.

For further information circle No. 23 on literature request card, page 48-B.

Filler Rod

A low-fuming gas filler rod for welding high-strength bronzes and

ANHYDROUS
AMMONIA
99.995%
PURE

OFFERED BY

HAMLER INDUSTRIES, INC.

While we pride ourselves on the pure ammonia we can offer you, we really feel proud about Hamler service. Fast dependable deliveries are our specialty.

Hamler service eliminates any and all shutdowns due to delays in receiving ammonia when YOU need it. A widespread fleet of trucks throughout the midwest means we can deliver the goods.

The service engineers from Hamler are ready if and when you need help at any time.

Hamler service is the best.

HAMLER
CAN SAVE
YOU MONEY

FIND OUT HOW,
CALL OR WRITE...

HAMLER INDUSTRIES, INC.

6025 W. 66TH STREET
CHICAGO 38, ILLINOIS

DETROIT 6560 Cass Ave. | PITTSBURGH P.O. Box 149 CARNEGIE, PENNA. | CLEVELAND 3537 Lee Road

BULK STATIONS AND TANK TRUCK DELIVERY FROM: CHICAGO, CLEVELAND, DAYTON, DETROIT, PITTSBURGH

12 B&W IFB lined single stack annealing covers in use in the strip annealing department of Weirton Steel Company, a division of National Steel Corporation, at Weirton, West Virginia.

WEIRTON STEEL COMPANY uses lightweight B&W Insulating Firebrick for single stack annealing covers.

These 12 covers, lined with B&W K-20 Insulating Firebrick, have been in service more than two years in the annealing of low and high carbon strip from Weirton's 54" strip mill. Identical in construction, the covers are over 17 feet from base to skew and over 10 feet in diameter. The domes are of 9" K-20 IFB construction.

The K-20 is one of B&W's *lightweight* Insulating Firebrick. In fact, B&W K-20 IFB are at least a third of a pound lighter than other 2000 F insulating firebrick. This means savings in the overall weight of portable covers. Additional savings in fuel consumption and cycle time are possible because lightweight B&W IFB store and conduct less heat. Heat is kept in the furnace, not in the lining.

This application points out advantages of light weight in insulating firebrick constructions. And B&W makes the *lightest* weight insulating firebrick. Consult your B&W Refractories Representative for information on how you can profit with lightweight B&W IFB.

Bulletin R-2-H available on request.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

B&W REFRACTORIES PRODUCTS:
B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide • B&W Ramming Mixes • B&W Kaowool

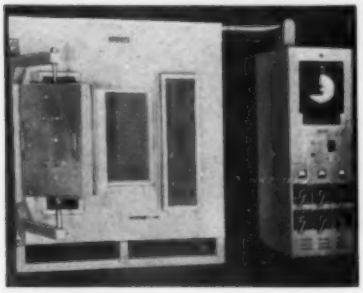
R-617

brasses has been announced by Ampco Metal, Inc. It is produced from manganese bronze alloyed with nickel for higher tensile strength, better ductility and greater toughness. It meets AWS-ASTM classification R-Cu Zn-B and Federal Specification QQ-R-571a, Class FS-R Cu Zn-3. It may be applied in all positions using regular gas brazing and braze-welding techniques and fluxes.

For further information circle No. 24 on literature request card, page 48-B.

Furnaces

Electric Furnace Div. of Harrop Ceramic Service Co. has announced a unit 36 by 41 by 41 in. for test operations or small-scale production use. Heating elements of silicon carbide provide an operating range up to



2800° F., with the normal furnace input of 50 kva. provided by a transformer of 100 kva. capacity. Furnace shown is equipped for full program control. The 400-lb. yoke-mounted door assures a tight seal while the furnace is in operation.

For further information circle No. 25 on literature request card, page 48-B.

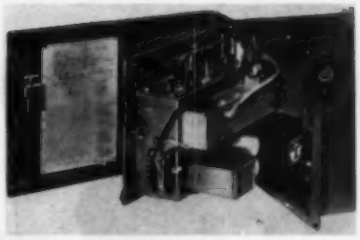
Inspection

A new industrial image amplifier, using electronic equipment to amplify an X-ray image and transfer it to a television screen, has been announced by Picker X-Ray Corp. The image is several hundred times brighter than a fluoroscope image and enables the radiographer to work in normal light rather than a darkroom. The three basic units for this method of inspection are the electronic image amplifier, the X-ray generator and a control. In addition to direct viewing, television and a movie camera can be used.

For further information circle No. 26 on literature request card, page 48-B.

Atmosphere Control

Mine Safety Appliances Co. has announced an infrared analyzer for atmosphere control of heat treating operations. It measures dew point, carbon monoxide, methane and other hydrocarbons. Accuracy is 1% of full scale, with a speed of response equal



to 90% of final reading in 5 sec. It is automatic and continuous in operation. The instrument operates on the principle of direct deflection. It can be used with an integral indicating meter as well as a recorder.

For further information circle No. 27 on literature request card, page 48-B.

Brazed Wire Cloth

The Cambridge Wire Cloth Co. has announced an industrial wire cloth that is brazed after weaving to prevent shifting of the wires in installations where the material is subjected to severe vibrations. It is currently being produced in 8 by 8 mesh from 0.020 in. diameter 304 stainless steel wire.

For further information circle No. 28 on literature request card, page 48-B.

Welder

Harnischfeger Corp. has announced a new a.c. welding machine for jobs that come within the range of 20 to 180 amp. It has 16 steps of heat and a high open circuit of 65 volts which permits the use of low-hydrogen and

stainless steel electrodes up to 3/16 in. Power supply of 230 volts, 50 to 60 cycles, single phase is required.

For further information circle No. 29 on literature request card, page 48-B.

Oven Heating

An indirect firing system for heating ovens where products of combustion are undesirable has been announced by the R. C. Mahon Co. The two chief features are the manifolding employed and the method of handling large volumes of recirculated air. Two sizes of heaters can be either gas

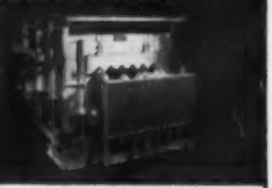
CUT COSTS, BOOST EFFICIENCY WITH

KOZMA

RADIANT FURNACES!

Kozma Radiant-fired Furnaces combine intense heat radiation with faster, more uniform heat absorption to increase efficiency and lower costs on all forging and melting operations.

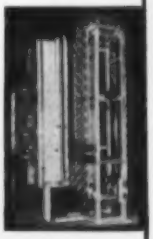
PUSHER-TYPE FORGING FURNACES



Designed to heat 3,600 lbs. per hour to 2,250° F, this pusher-type forging furnace heats at rates up to 135 lbs. per sq. ft. of hearth area. Radiant burners eliminate flame impingement, reduce scale and increase die life. Available in a wide range of capacities.

VERTICAL CONTINUOUS END-HEATING FURNACES

This radiant-fired, vertical continuous end-heating furnace heats steel bars or tubes to proper forging temperatures quickly and efficiently. Offers increased fuel economy over horizontal-type furnaces. Can be easily adapted to automatic loading. Capacities to meet your needs.



TILTING REVERBERATORY ALUMINUM MELTING FURNACE

NEW!

These new Kozma Furnaces for aluminum melting combine all the advantages of radiant cone heating with functional tilting design. They feature charging wells and integral ladle suspension arms for convenience. Provide faster melting rate, increased fuel economy, lower melting costs.

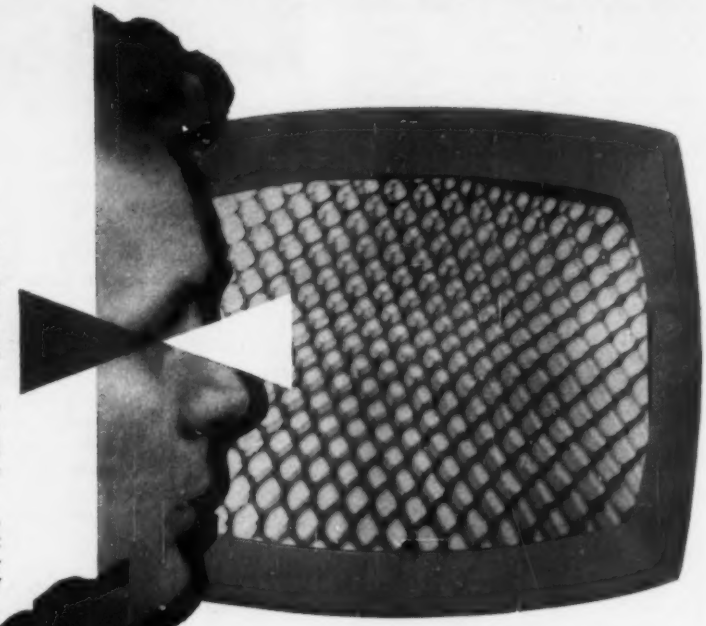
WRITE FOR COMPLETE INFORMATION!

J. A. KOZMA Company
2471 WYOMING
DEARBORN, MICHIGAN

"Industrial Processing Furnaces Since 1928"

General Electric x-ray in industry

New look in x-ray inspection!

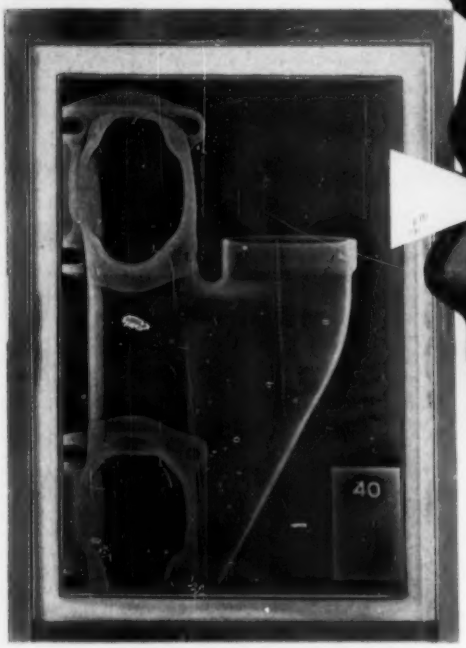


GENERAL ELECTRIC TVX— instant, continuous production-line inspection

Put your inspection program on television! General Electric's TVX x-ray image intensification system is literally a closed-circuit telecast of your production line, with the picture formed by an x-ray sensitive camera. View it anywhere — in another room, another building — within 1400 feet of the monitor.

TVX is 100% safe for the inspector. You can use any intensity you need with the monitor remote from the radiation area. Versatile too, it will vary image size from ½ to 3 times that of the object. Intensifies as it magnifies.

The system uses a conventional x-ray generator, and a monitor with a 12-in. picture tube (at right showing honeycomb weld) bright enough for viewing in normal room light. Any standard TV receiver will do as an additional monitor.



XERORADIOGRAPHY— a permanent record in less than a minute

Exciting news for inspection of light alloy castings, weldments, small assemblies. Xeroradiography (zero-radiography) lets you view results *within one minute after exposure!* If flaws are revealed, corrections can be made immediately, before expensive machining.

Developed by Haloid Xerox, Inc., with the cooperation of General Electric X-Ray — Xeroradiography is a "dry" method of 100% inspection — requires no x-ray film, no darkroom, no processing solutions. Metal plates are re-usable. And it operates easier than it spells!

The plate at left typifies the outstanding clarity offered by xeroradiography. It also has the happy habit of highlighting defects with unusual emphasis.

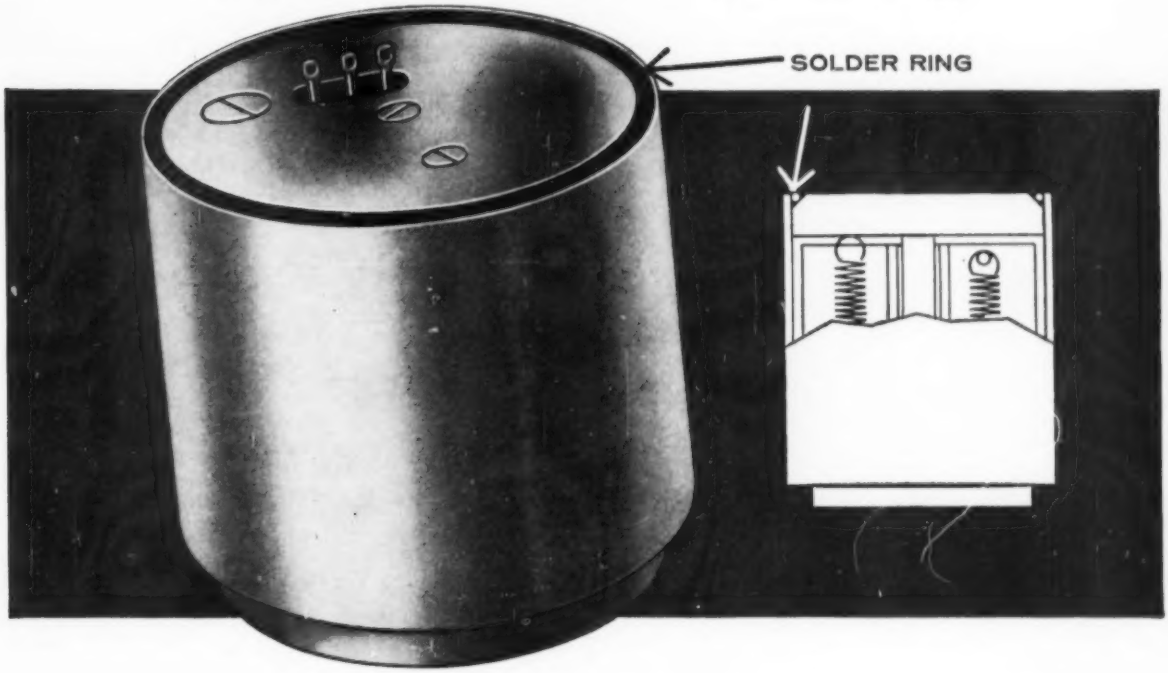
Your General Electric x-ray representative is the fellow to see for more information. Or, you can get specs and features data by writing General Electric X-Ray Department, Milwaukee 1, Wisconsin, Room AS14.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Precision soldering 7 Times Faster...

with TOCCO* *Induction Heating*



When G. M. Giannini and Co., Inc., Pasadena, California, switched from old-fashioned methods to TOCCO Induction Heating they increased production of these high-precision accelerometers from 4 to 30 per hour—with a commensurate *decrease* in production costs.

Here's what a Giannini official has to say about the TOCCO installation: "Prior to using TOCCO for this purpose, we had tried soldering irons, normal torches, resistance sealing, and even threaded screw fittings, with uniformly poor results. Essentially, the TOCCO unit has permitted us to build, in production quantities, oil-filled hermetically sealed units that could not be produced in any other way."

Whether your production bottleneck involves soldering, brazing, heat treating or heating for forming it pays you to investigate TOCCO as an economical way to do it better, faster and at lower cost.

TOCCO

THE OHIO CRANKSHAFT COMPANY

Mail Coupon Today— NEW FREE Bulletin

The Ohio Crankshaft Co. • Dept. R-1, Cleveland 5, Ohio

Please send copy of "Typical Results of TOCCO Induction Brazing and Soldering".

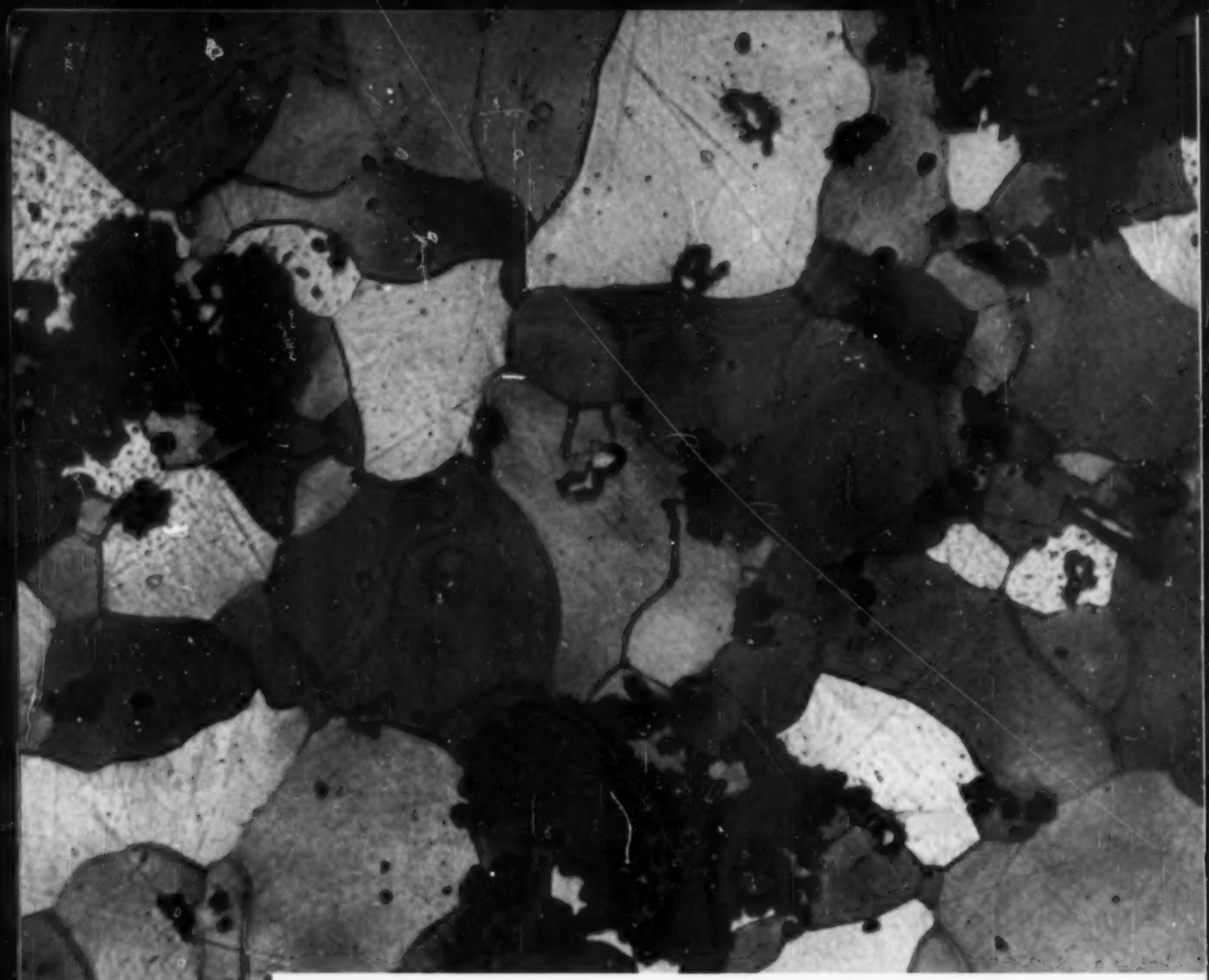
Name_____

Position_____

Company_____

Address_____

City_____ Zone____ State_____



Color micrograph of heat tinted section of ferritic Malleable iron showing random dispersion of temper carbon nodules in ferrite. 625X magnification.

Usability is Malleable

In the growing world of metals, certain requirements remain basic: strength . . . versatility . . . economy. Malleable iron castings uniquely answer all three. Malleable castings provide more strength per dollar than any other metal . . . are the most machinable of all ferrous metals of similar hardness.

From the great range of Malleable irons now produced in modern Malleable foundries, you can select exactly the right metal to fill your most demanding needs for endurance, resistance to impact and wear, ductility and constant uniformity. No other metal offers you so much at so low a cost.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, 1800 Union Commerce Building, Cleveland 14, Ohio, for information.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Badger Malleable & Mfg. Co., S. Milwaukee
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

How to Select the Best Metal to Perform a Given Set of Functions

Any equipment part can be described, at least approximately, in terms of the functions it must perform. That is, it must provide a certain strength plus resistance to wear, fatigue, impact or corrosion. The finished part must provide the best combination of all necessary factors at the lowest possible cost — a cost that must include machining, finishing and assembly where applicable.

Unique Production Method Combines Desirable Characteristics

The amount and form of carbon in ferrous metals is of prime importance. The carbon content of Malleable iron (2.00 to 2.60%) provides good fluidity at the pouring stage. Yet neither flake graphite nor combined carbon is present in finished standard Malleable iron.

As the photomicrograph of standard Malleable iron shows, the carbon has been transformed into temper carbon nodules in a matrix of ferrite during the heat-treatment given *all* Malleable iron castings. The result is a metal with a unique combination of high strength, toughness and machinability.

Pearlitic Malleable irons differ from standard, or ferritic, Malleable only in that a controlled amount of the carbon is combined with the iron to form a pearlitic matrix around the temper carbon nodules. This increases strength, hardness, wear resistance and modulus of elasticity, while retaining good ductility and machinability.

TENSILE PROPERTIES — A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons				
Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Elongation % in 2 in.	Ratio of Tensile to Yield %
Standard				
35018	53,000	35,000	18	66
32510	50,000	32,500	10	65
Pearlitic				
45010	65,000	45,000	10	69
45007	68,000	45,000	7	66
48004	70,000	48,000	4	69
50007	75,000	50,000	7	67
53004	80,000	53,000	4	66
60003	80,000	60,000	3	75
80002	100,000	80,000	2	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

TYPICAL BRINNELL HARDNESS NO. RANGES

Pearlitic Malleable Irons							
Designation	45010	45007	48004	50007	53004	60003	80002
B. H. N.	163-207	163-217	163-228	179-228	197-241	197-255	241-269

New Savings Result

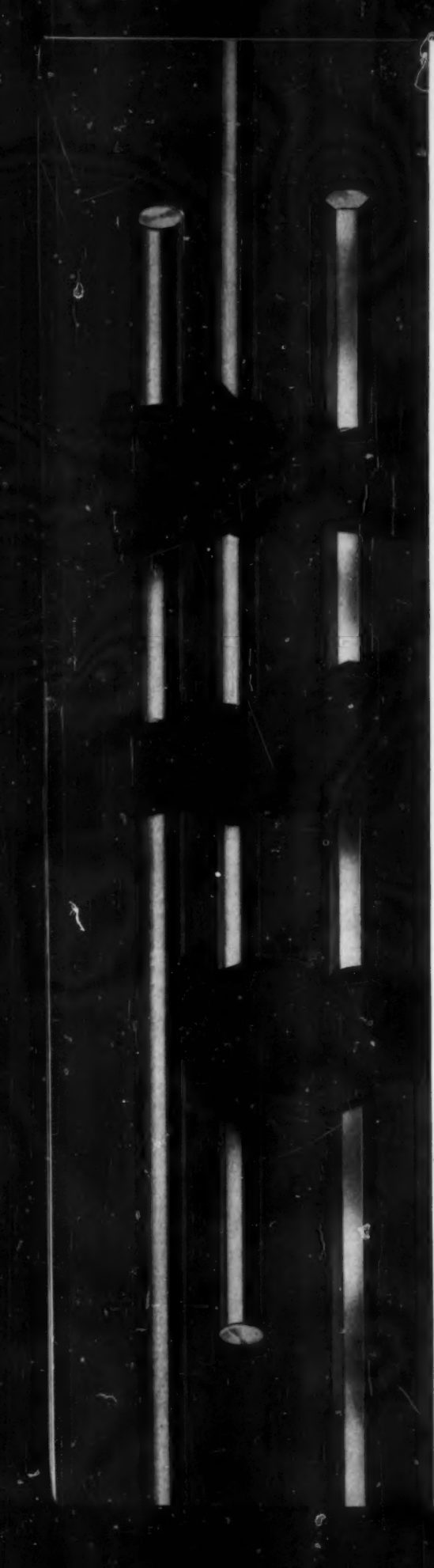
From the wide range of properties obtainable, a Malleable iron may be selected that will most completely meet ideal design and functional requirements. Because of the great latitude of producible sizes, from a fraction of an ounce to hundreds of pounds, Malleable can be used for a wealth of applications.

Malleable iron's economy is derived in two ways. First, the casting process is generally accepted as the most economical method of producing a finished part. Secondly, being the most machinable of all ferrous metals of similar hardness, cast or otherwise, Malleable iron castings provide exceptional economies in time, tool and power consumption.

Today's Malleable iron castings offer tremendous strength, uniformity, versatility and economy. The producers of Malleable castings are anxious to assist you in getting maximum "usability." Why not let their modern design, testing and production facilities work for you?

Send for Special Data Unit

Your copy of Data Unit No. 101 containing additional information on the benefits you can derive from Malleable iron castings is available from any member of the Malleable Castings Council. If you wish, you may direct your request to **Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.**



An announcement of interest to manufacturers of steel parts

Improvements in today's STRESSPROOF STEEL BARS WITH COPPER

1 **100,000 PSI YIELD STRENGTH** in all sizes . . . without heat treating.

2 **IMPROVED PHYSICAL PROPERTIES**... better fatigue life wearability, and resistance to atmospheric corrosion. Over-all quality is improved.

3 **IMPROVED MACHINABILITY**... STRESSPROOF with copper now machines faster and better than ever. It gives longer tool life, better finish, and more production from a day's run, according to shop production records.

4 **CLOSER TOLERANCES**... Tolerances for rounds have been tightened to meet the need for more precise parts as follows:

¼" to 1½"	Over 1½" to 2½"	Over 2½" to 3⅜"
+.000 −.004	+.000 −.005	+.000 −.006

5 **COMPARED WITH OTHER STEELS, STRESSPROOF COSTS EVEN LESS TODAY**... Also saves machining and heat treat costs, and you get a better quality part. It will pay you to take another look at this improved material.

Your STEEL SERVICE CENTER stocks contain today's STRESSPROOF. It has been produced and shipped over a several months' period.

JUST PUBLISHED! Use this coupon to request your copy of new bulletin, "Improvements in Today's STRESSPROOF Steel Bars."

La Salle STEEL COMPANY
1424 150th Street, Hammond, Indiana

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

or oil-fired. The larger unit will measure 7 by 2 by 7 ft. and will require no brickwork in its installation.

For further information circle No. 30 on literature request card, page 48-B.

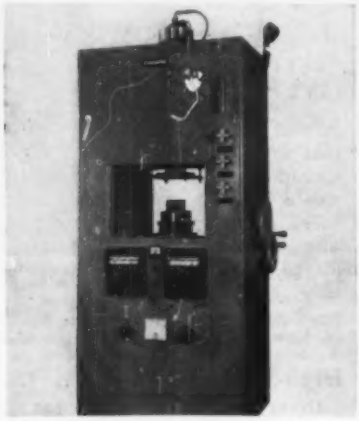
Magnet Wire

A new line of aluminum magnet wire has been announced by the Aluminum Co. of America. The wire will be offered in AWG sizes No. 12 through 24, and will be available on spools or in pails. The aluminum wire will be manufactured with Formvar, Nyform and Isonel insulations.

For further information circle No. 31 on literature request card, page 48-B.

Atmosphere Furnace

A new high-temperature atmosphere furnace of vertical design for pilot plant or laboratory applications has been announced by the Pilot Plant



Div. of Lindberg Engineering Co. It has a cooling chamber and stepless temperature control to 2750° F. All electrical components are in the bottom portion of the cabinet.

For further information circle No. 32 on literature request card, page 48-B.

Radiant Heating Tubes

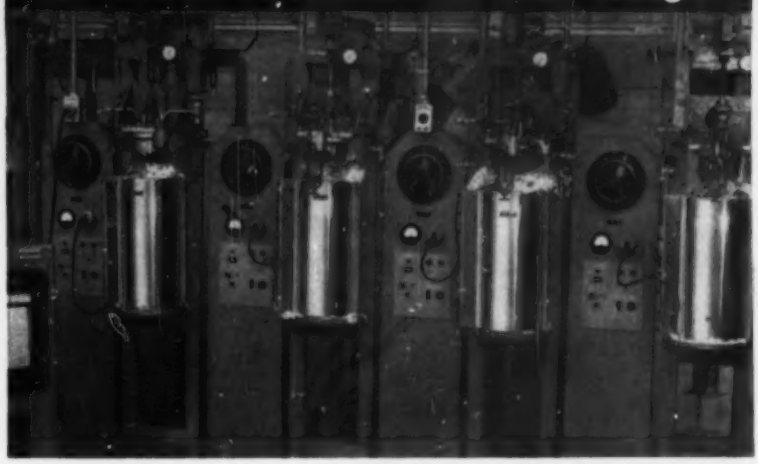
The McDanel Refractory Porcelain Co. has announced larger-size ceramic tubes for radiant-type heating furnaces. Tubes 72 in. long and 2 to 4 in. in diameter are being produced. Accessory equipment includes ceramic flame diffusers.

For further information circle No. 33 on literature request card, page 48-B.

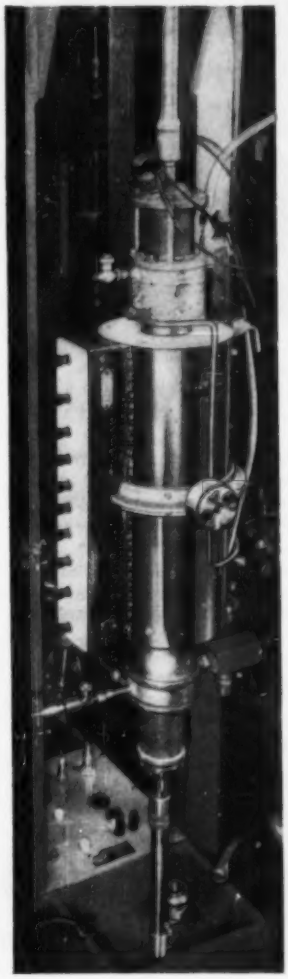
Coloring Zinc

Heatbath Corp. has announced chromate powder and solutions for producing metallic colors on zinc plate. They are made up using 1½ oz. per gal. of water plus a small amount of nitric acid. This produces a clear blue, bright, chromate film that can be dyed various colors. The dye solu-

Marshall Furnaces at Oak Ridge



1000 to 1800° F ± 1.5°



At Oak Ridge, Marshall furnaces accurately maintain set temperature levels in the range of 1000 to 1800° F., within ±1.5° F. The furnaces are vital components of specially designed and built gaseous and vacuum creep rigs. Creep properties of structural metals are tested under the effect of high temperature gases, vacuum, various liquids, and liquid metals. The furnaces were developed by the Oak Ridge National Laboratory, operated by Union Carbide Corporation for the U. S. Atomic Energy Commission, and built to their specifications by Marshall Products Co. After more than four years of virtually continuous service, all major components are still in operation!

This accuracy and dependability is typical of Marshall furnaces used widely as components of machines for creep testing metallic alloys, and also for tensile, stress-rupture, and fatigue testing of metals, ceramics and cermets.

Marshall offers a range of standard tubular, shunt-type furnaces compactly designed to apply electrical heat *up to 2600° F*, under exact control. Units feature *uniform temperature distribution* and *rigid zone control to ±3° F* at any part inside the furnace. Under certain conditions operators report temperatures can be held to ±1° F. Test durations may range from moments to 10,000 or more hours.

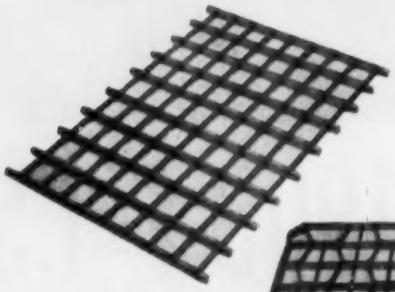
MARSHALL PRODUCTS CO.
tubular furnaces and control panels
270 W. LANE AVENUE, COLUMBUS 2, OHIO

write today for complete information

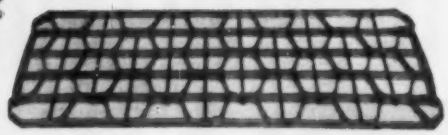
Liquid-metal creep testing frames (shown at top)
Creep frame for testing gaseous environments (left)

ROLOCK
FABRICATED ALLOYS
HEAT AND CORROSION RESISTANT

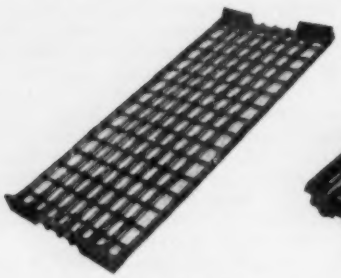
SILVER PLATTER SAVINGS
are served with these
ROLOCK TRAYS



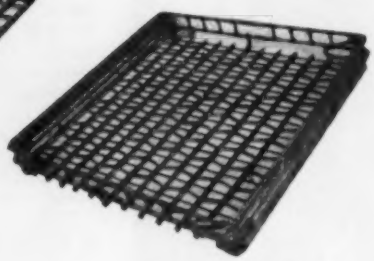
"Pressure Welded"
Furnished 2-layer
or 3-layer



"Serpentine"



"Pressure Welded"
with pusher pads



"Serpentine"
with load-retaining sides

ROLLER HEARTH FURNACE users have found these two basic Rolock Tray designs . . . and many possible variations . . . at once efficient and economical.

Not only can Rolock design and construction reduce tray weight (often by 25% to 50%) and thus increase pay-load, but service records frequently show that tray life has doubled or tripled.

These worthwhile savings have resulted from Rolock's engineering approach to tray design, taking into consideration details of the furnace hearth, tray load and weight ratios, method of operation, temperature limits and gradients and many other factors.

Complementing correct design, Rolock's unique "Serpentine" and "Pressure-Welded" construction features have proved to be, in many installations, the answer to problems of rapid tray deterioration. That is why Rolock today is a major supplier of furnace trays of these and many special types.

Why not make your own test. Let Rolock design and build your next replacements.

SALES AND SERVICE REPRESENTATIVES FROM COAST TO COAST

ROLOCK INC., 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

IRL39

tions are made up using ⅛ to ⅛ oz. of dye powder per gallon of water.

For further information circle No. 34 on literature request card, page 48-B.

Laboratory Furnace

Harrop Electric Furnace Div. has announced two new furnaces for laboratory test firing in the intermediate temperature range. For 2000° F. operating maximum, nichrome wound elements are used while Kanthal windings are used for 2300° F. operation. Either model provides a setting space 18 by 18 by 19 in. and is wired for 220 v. single-phase power supply. The MR-18C speed at 230 v., loaded, is 5½ hr. minimum from 70 to 1800° F.

For further information circle No. 35 on literature request card, page 48-B.

High-Strength Steel

Great Lakes Steel Corp. has announced a new line of high-strength steels. They are fine-grained, mild carbon steels of high strength, toughness and weldability. GLX-W steels are available in yield strengths from 45,000 to 60,000 psi.

For further information circle No. 36 on literature request card, page 48-B.

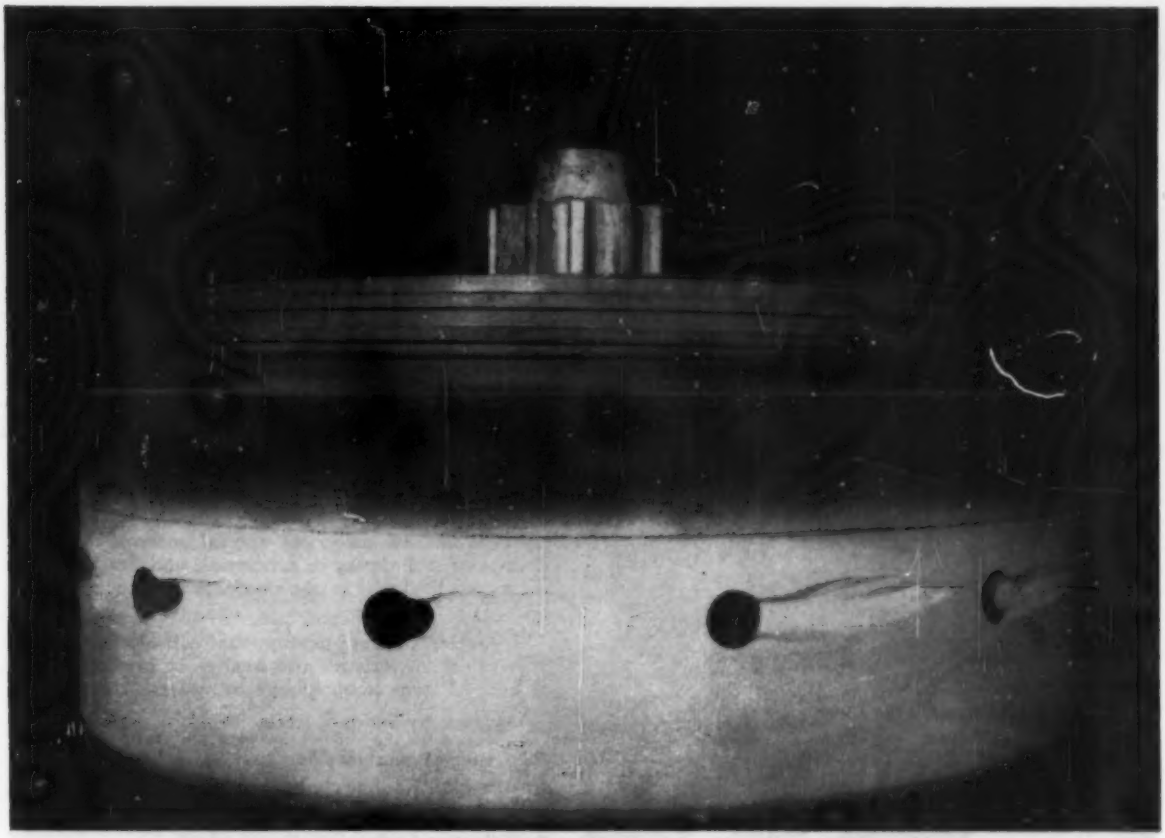
Titanium Alloy

Mallory-Sharon Metals Corp. has announced a new titanium alloy MST 881, which maintains long-time strength properties at temperatures to 1100° F. Chief applications will be in jet engines, manned aircraft and missiles. It contains 8% Al, 8% Zr, and 1% Ta + Cb.

For further information circle No. 37 on literature request card, page 48-B.

Generator

A new radiofrequency generator with a minimum output rating of 25 k.w. at a frequency of 450 kc. has been announced by Welduction Corp. This generator is used to supply radiofrequency power for metal hardening, drawing, melting and brazing



The Georgia Kaolin Company, well-known manufacturer of industrial clays, reports that they have made substantial savings by coating worn separator centrifuge bowls with Norton ROKIDE "A" coating. Worn bowls were previously returned to their manufacturer after six to eight months of high speed service for restoring to their original condition. But now Georgia Kaolin applies ROKIDE "A" coating before the bowls become badly worn . . . and at a fraction of repair cost at the factory. Service life is greatly extended. Maintenance costs and down time are substantially reduced.

How ROKIDE* Coatings increase service life, cut maintenance costs of moving parts

ROKIDE coatings are applied by heating the end of a ceramic rod and projecting the molten particles at high velocity. Reaching a prepared surface, they adhere and solidify. Protecting parts of a wide variety of sizes and shapes, these coatings are in extensive, rapidly increasing use in military and general industrial applications.

Three types of ROKIDE spray coatings — "A" aluminum oxide, "ZS" zirconium silicate and "Z" zirconium oxide — are hard, adherent, crystalline refractory materials. Parts, particularly metals, on which these coatings are especially useful are those requiring thermal or electrical insulation . . . resistance to wear or corrosion . . . excellent mechanical strength . . . dimensional stability . . . relative chemical inertness.

Possible applications: bearing surfaces, metal rolls, feed rolls, nozzles, pump shafts, thermocouple tubes and wire, mechanical seals, extrusion dies, laboratory molybdenum boats, vibratory feed hoppers, metal guides, metal melting pots, sanding fixtures, induction heating coils, strain gages, and applications in the wire industry.

Norton maintains facilities for applying ROKIDE coatings at Worcester, Mass., and at its plant 2555 Lafayette Street, Santa Clara, California. For further facts, write to NORTON COMPANY, New Products Department, 320 New Bond Street, Worcester 6, Massachusetts.

*Trade Mark Reg. U. S. Pat. Off. and Foreign Countries

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NEW PRODUCTS

Making better products . . . to make your products better

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — BEAR-MANNING DIVISION Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

Why SANDVIK has so many different kinds of high carbon and alloyed steel

SANDVIK high carbon and alloyed steels are *specialized* steels. Each type is fitted for a specific service; "custom-tailored" to meet certain exacting physical demands.

Purity of raw materials, special analyses, highly developed techniques in processing and finishing — these are all factors in the production of specialized SANDVIK steels.

If you have an application that calls for unusual physical characteristics and quality in high carbon or alloyed strip steel, 'phone or write SANDVIK.

You can get Sandvik steels

- **In special analyses for specific applications**
- **Annealed, unannealed or hardened and tempered**
- **With bright finish or blue or yellow polished**
- **With round edges or square edges**
- **In a wide range of thicknesses from .001".**

...can get complete information, promptly, ...st.

55-24

Write for new Sandvik brochure and stock lists.

SOME SANDVIK SPECIALTY STRIP STEELS
Band Saw Steels • Camera Shutter Steel • Clock and Watch Spring Steels Compressor Valve Steel • Doctor Blade Steel • Feeler Gauge Steel • Flapper Valve Steel • Knife Steels • Matrix Band Steel • Needle Cutter Steel • Piston Ring Segment and Expander Steels • Razor Blade Steel • Reed Steel • Shim Steel Shock Absorber Steel • Sinker Steel Spring Steels • Textile Steels • Vibrator Reed Steel

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Works: Sandviken, Sweden

applications. The unit has six wide swing saturable reactors for heat control adjustment. Lights and multicolor meters show up operating irregularities.

For further information circle No. 38 on literature request card, page 48-B.

Ferroalloys

Two new high-chromium extra-low-carbon ferroalloys have been announced by Vanadium Corp. of America. The new alloys have a minimum chromium content of 75% and maximum carbon of 0.015 or 0.025%, making them useful in the production of stainless steels and high-temperature alloys.

For further information circle No. 39 on literature request card, page 48-B.

Custom-Clad Materials

Riverside-Alloy Metal Div. has announced clad materials with a variety of alloys as sheathing and core. The new materials are used in applications subject to corrosive influence and requiring good mechanical and thermal properties. Combinations use Monel, nickel, Inconel, stainless steel and other special alloys.

For further information circle No. 194 on literature request card, page 48-B.

Conveyor Belts

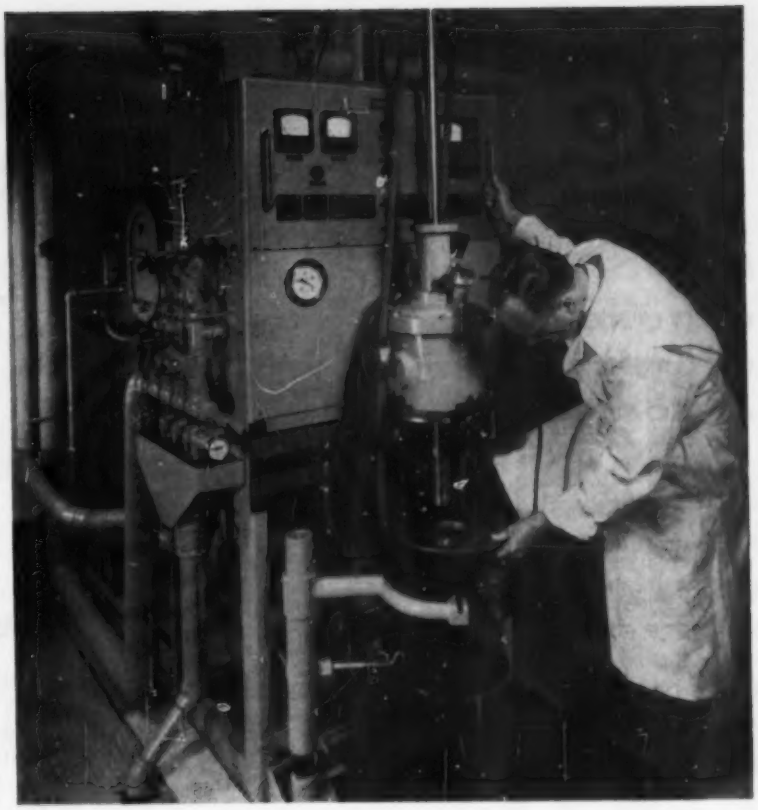
Ashworth Bros., Inc., have announced the addition of a new series of heavy-duty flat-wire belts to their line of metal process belts. The design balance built into these new heavy-duty belts results in a favorable belt-strength to belt-weight ratio.

For further information circle No. 195 on literature request card, page 48-B.

Microscope

Edmund Scientific Co. has announced a triple nosepiece microscope. It has three small, color-corrected lenses. Nosepiece rotates to bring objective into alignment. It swivels at its base for inclined viewing. A plano substage mirror illuminates viewing area and slides. Applications include edge-checking of precision metal work and examination of precision tools.

For further information circle No. 196 on literature request card, page 48-B.



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NEW SPACE-AGE METALS

in this high-vacuum furnace

He's purifying conventional metals and alloys under very low pressure—pumping away the impurities that are liberated—and producing melts so pure that they are essentially new metals. New metals of higher resistance to heat and fatigue. New metals that only vacuum metallurgy can produce.

This VA-L-200H Heræus Vacuum Arc Furnace is a laboratory or small-scale production model with a crucible volume of 250 cu. in. It's the smallest in a complete line that will give you the same highest-purity melts in capacities up to 6600 lbs.—even higher with special-order units. There's a unit just right to help you keep pace with space-age metallurgy. We'd like to talk to you about it.

Write for application data and specifications. Just ask for Arc Furnace Bulletins.

Consolidated Electrodynamics

Rochester Division, Rochester 3, N.Y.

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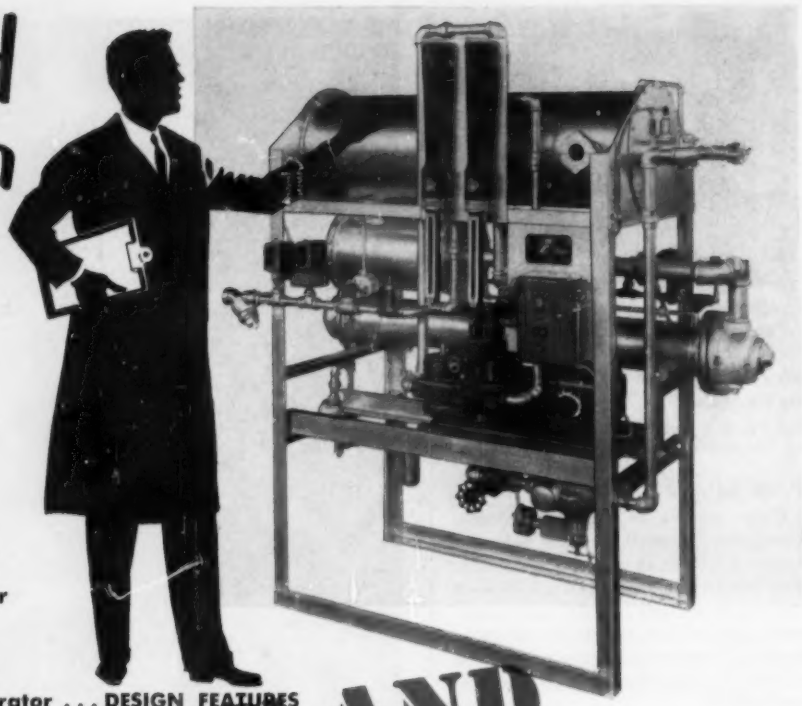
For added protection

CHOOSE HAYES PROTECTIVE ATMOSPHERES!

Proper atmosphere equipment increases production, improves product quality, and makes your processing more economical!!



HAYES Type G Exothermic Generator . . . DESIGN FEATURES

For conveyor or pusher type furnaces requiring protective atmospheres of an exothermic [illegible] reducing type, the Hayes Type G Exothermic Gas Generator offers [illegible] advantages [illegible]

- **ELECTRIC IGNITION SYSTEM** for added safety! Simple, effective design, stainless steel construction. Located out of actual combustion chamber to prevent burn out.
- **AUTOMATIC COMBUSTION CONTROL** is [illegible] by self-adjusting mixing device which [illegible] the [illegible] combustion [illegible] eliminating the need for manual [illegible] of the gas-air valves.
- **HEAT EXCHANGER** designed with easily accessible, straight tubes . . . facilitates cleaning without disassembly.
- **FLOW METERS** give accurate indication of actual, not relative, flow measurements.
- **SPECIAL FEATURE AVAILABLE** to adapt standard model to glass-to-metal sealing applications. Request details.
- **STANDARD SIZES** range from 200 CFH to 4000 CFH. Larger sizes also available.

NITROGEN AND FORMING GAS GENERATORS, TOO!

Hayes Type IGL Endothermic Generator incorporates many of the above [illegible] is [illegible] providing [illegible] which [illegible] ing [illegible] for carbon [illegible] . . . giving protection to medium or high carbon steel. Provides for the close control of retort temperatures, complete control of gas and air ratio and subsequent atmosphere dew point. Request complete data!

Hayes Type AG Ammonia Dissociator [illegible] . . . produces comparatively inexpensive hydrogen-nitrogen atmosphere of extreme purity and very low dew point. Such atmospheres are required for heat treatment of stainless steels and are extremely helpful in providing protection where exothermic atmospheres are not adequate.

Hayes Molecu-Dryer, a new concept in air and gas drying, effectively removes moisture down to a dew point of —100°F. Request complete data.

Hayes Service Engineers assist customers in starting their equipment and adjusting it to meet their exact requirements. Whatever your heat treating problem, bring it to the unique Hayes Laboratory for recommendations!!

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Request Bulletin 256 for complete information on Hayes Atmosphere Equipment. Let us show you how to improve your product, increase output, and reduce unit costs . . . with RESULTS GUARANTEED! Check literature desired on any of the following procedures . . . write today!

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- ☐ High Speed Hardening
- ☐ Tool Steel Hardening
- ☐ Carbo-Nitriding
- ☐ Tempering
- ☐ Bright Heat Treating
- ☐ Stainless Steel Heat Treating
- ☐ Sintering
- ☐ Copper Brazing and Soldering
- ☐ Lead Pot Hardening and Tempering

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Company _____

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City and State _____

APPLICATION and EQUIPMENT new literature

40. Abrasive Cleaning
Folder on Malleabrasive for airless blast cleaning equipment gives advantages, grades, equipment it can be used with and parts that can be cleaned. *Globe Steel Abrasive*

41. Alloy Powder
New bulletin gives technical data on alloy powder HS 6460 including properties, specifications and heat treating recommendations. *Republic Steel*

42. Alloys
New pamphlet on iron foundry alloys details composition, uses and advantages of 31 ferroalloys for both cupola and electric furnace irons. *Vanadium Corp.*

43. Alloy Steels
New 46-page Booklet 415-C on alloy steels. 9 pages of tables giving chemical composition ranges, limits. Grain size, heat treatment, quenching mediums. *Bethlehem Steel Co.*

44. Aluminum Bronze Alloys
New 20-page booklet on chemistry, physical properties and uses of aluminum bronze alloys in rolled, extruded and cast form. *Ampco*

45. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

46. Aluminum Extrusions
Folder lists alloys used, finishes, trade phraseology. *General Extrusions*

47. Aluminum Extrusions
Catalog of extrusion dies in stock. *Jarl Extrusions*

48. Aluminum Strip
20-page booklet on how it is made, sizes and weights of coils. Technical data on aluminum alloys used. *Scovill*

49. Ammonia
Data on anhydrous ammonia plants and standby gas plants. *Peacock Corp.*

50. Annealing
New brochure describes and pictures precision annealing technique. Photomicrographs show grain structure. *Waterbury Rolling Mills, Inc.*

51. Atmosphere Control
New 8-page Bulletin SC-178 on furnaces, atmosphere equipment, controls for bright annealing, hardening and tempering, batch annealing, age hardening and carburizing. *Surface Combustion*

52. Atmosphere Furnaces
New brochure describes various hydrogen atmosphere furnaces for heat treating and brazing stainless steels. Ammonia dissociators for use with this equipment. *American Gas Furnace*

53. Atmospheres
New Bulletin I-107 supplies technical information on inert gas generators. Composition of gases, specifications. *C. M. Kemp*

54. Atmospheres
New 4-page newsletter bulletin on atmosphere heat treating and processing. Other applications. *Ferrotherm*

55. Barrel Cleaning
Data sheet on Model RD/2 barrel machine for deburring, descaling, burnishing, polishing. Size and capacity. *Casalbi*

56. Blast Cleaning
New 12-page booklet on blast cleaning equipment. Describes vacuum-cast heat treated steel abrasive. *Pangborn*

57. Brazing
16-page pocket-sized guide to selective fluxing for low-temperature silver brazing. *American Platinum*

58. Calibration
New Bulletin 169 on calibrating and weighing system. Advantages, construction, operation, specifications. *Morehouse Machine*

59. Carbides
New 22-page catalog on tungsten, titanium, columbium and tantalum carbides. Physical and mechanical properties. Applications. *Kennametal*

60. Castings
New 8-page brochure on the centrifugal casting process. Illustrations describe applications. *Centrifugal Casting Co.*

61. Castings
Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

62. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

63. Cleaner
New Folder F 10466 on nonetching reverse current cleaner. Recommended procedures, applications. *Oakite*

64. Cleaning Aluminum
12-page bulletin on cleaning process for preparing aluminum and magnesium for welding. *Northwest Chemical*

65. Coating Thickness Tester
Data sheets give ranges, principle of operation of nondestructive thickness tester. *Unit Process Assemblies*

66. Cold Finished Steel
16-page booklet on 10 grades of cold finished steels. Analysis, machinability, heat treatment, wear resistance. *Jones & Laughlin*

67. Combustion System
New Bulletin No. 115 on submerged combustion system. Construction, fuels, control and safety equipment. Diagrams. *Thermal Research & Engineering Corp.*

68. Controls
Bulletin 658 on saturable reactor for regulation and control of electric ovens and furnaces. *Sorgel Electric Co.*

69. Creep Testers
Pocket-size creep load calculator that determines the pounds of weight needed on weight pan when testing specimens in creep testers. *Arcweld Mfg. Co.*

70. Creep Testers
Article in Metal Digest V. 4, No. 5, discusses creep testing machines for research and production. *Buehler, Ltd.*

71. Degreasers
Folder on vapor and solvent degreasers describes equipment and advantages. *Randall Mfg.*

72. Descaling Stainless Steel
Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

73. Ductility Testing
Bulletin on simple method of determining ductility of materials before drawing. *Steel City Testing Machines*

74. Electric Furnaces
8-page Bulletin 570 on heat treating, melting, metallurgical tube, research and sintering furnaces. Custom designs for special requirements. *Pereny*

75. Endothermic Atmospheres
16-page reprint on endothermic atmospheres for heat treatment of steel. Effect of temperature on atmosphere. Calculating analysis. *Electric Furnace Co.*

76. Forgings
Folder on facilities for production of flat-die forged products. Electronic equipment used. *Smith-Armstrong*

77. Formed Plate
Bulletin on stainless steel elliptical flanged and dished heads. 171 available dies listed. *G. O. Carlson*

78. Formed Shapes
28-page catalog No. 1555 contains drawings and dimensions of more than 100 shapes. *Roll Formed Products Co.*

79. Freezer
Data on chest for use down to −95° F. for production and testing. *Revco*

80. Furnace Fixtures
16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood*

81. Furnaces
New Bulletin 5710 on conveyor furnaces for operation to 2150° F. Specifications of standard straight through and "humpback" furnaces. *C. I. Hayes*

82. Furnaces
New 6-page Bulletin No. C-80 on soft metal reverberatory furnace. Three models described. Advantages. *Hevi Duty*

83. Furnaces
Brochure describing heating, treating, processing and laboratory furnaces. *L & L Mfg. Co.*

84. Furnaces
12-page catalog on electric heat treating furnaces. Data on each of 57 models. Controls, instruments, elements and accessories. *Lucifer Furnaces, Inc.*

85. Furnaces
New 8-page Bulletin 70 on metal melting and heating equipment. Design, melting performance table. *Inductotherm*

86. Furnaces
New catalog on furnaces and ovens for laboratory or production. *K. H. Huppert*

87. Furnaces
Bulletin on metallurgical test furnaces for tensile, creep and stress-rupture tests. Control panels. *Marshall Products*

88. Furnaces
New Bulletin 200 describes complete

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Completely NEW concept in metal cleaning!

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- Effective on *all* metals.
- Requires NO special tanks or equipment.
- A completely organic product.
- Won't injure rack coatings or work finish.
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Alkalume LC-1 is a specially developed immersion-type cleaner for removal of buffing compounds and soil from all metals, prior to plating or anodizing.

It is non-solvent, non-alkaline and not an emulsion. It has the desirable penetrating properties of both alkali and solvent yet affords complete protection for the surface finish.

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setup for heat treatment of small tools, including draw furnace, quench tank and high-temperature furnace. *Waltz Furnace*

89. Gold Plating
8-page paper gives bath composition, equipment and operating conditions, and metallurgical characteristics of 24K gold plate on various base metals. *Sel-Rex*

90. Graphite Electrodes
New 6-page folder describing graphite electrodes for electric furnaces. Stock list of threaded graphite electrodes and their corresponding nipples. *Great Lakes Carbon*

91. Hardening Tool Steels
4-page bulletin on complete line of hydryzing furnaces. Diagrams, specifications and performance data on preheat and high speed furnaces. *Lindberg Engineering*

92. Hardness Conversions
Desk-size chart of conversions for Rockwell tests and other hardness scales. *Torsion Balance Co.*

93. Hardness Tester
Catalog 72-1 on Leitz miniload tester for Vickers and Knoop hardness tests. *Opto-Metric Tools, Inc.*

94. Hardness Tester
Bulletin A-16 on microreflex hardness testers. Loads to 3000 gr. Zeiss optical system. *Gries Industries, Inc.*

95. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

96. Hardness Tester
Bulletin on how to test large gears with portable Brinell tester. *King Tester*

97. Hardness Tester
Data on portable hardness tester with Rockwell and Brinell scales. *Mechanical Devices*

98. Hardness Tester
Folder on portable hardness testers for testing of various sizes, shapes and types of metal. *Newage Industries*

99. Hardness Testers
New 20-page Catalog No. DH-326 on models, applications and how to use superficial hardness testers. *Wilson Mechanical Instrument Div.*

100. Heat Treating
Monthly bulletin on used heat treating and plating equipment available for immediate delivery. *Metal Treating Equipment Exchange*

101. Heat Treating
12-page bulletin on heat treating equipment. Applications and special features of 19 different types of furnaces including shaker hearth, conveyor, high vacuum, elevator-type brazing. *Pacific Scientific*

102. Heat Treating
20-page Catalog TD2-620(1) on various sized furnaces for steam atmosphere heat treating. Uses, corrosion and wear resistance, finish. *Leeds & Northrup*

103. Heat Treating Belts
New 12-page catalog of conveyor belts and data for their design, application and selection. *Ashworth Bros.*

104. Heat Treating Equipment
New 24-page Catalog 54 on light-weight processing and heat treating equipment. *Pressed Steel Co.*

105. Heat Treating Fixtures
32-page Catalog G-10A lists process equipment, heavy welded fabrications, muffles, trays, fixtures for furnaces, heat treating equipment, pickling equipment. *Rolock*

106. Heat Treating Fixtures
New 16-page Catalog M-7 on heat treating baskets and corrosion resistant alloy fabrications. *Wiretex Mfg. Co.*

107. Heat Treating Fixtures
Bulletin on formed and welded alloy heat treating furnace fabrications. *Alloy Engineering Co.*

108. Heat Treating Furnaces
Folder on industrial furnaces. Continuous designs. Insulation. *Pacific Industrial*

109. Heat Treat Pots
Catalog on pressed steel pots for lead, salt, cyanide, oil tempering and metal melting. *Eclipse Industrial Combustion*

110. Heaters
New Bulletin F-1613 on Chromalox electric strip heaters. How to use and chart of sizes and ratings. *Edwin L. Wiegand Co.*

111. High-Strength Steel
26-page booklet on properties, uses, applications of high-tensile low-alloy steel. *Jones & Laughlin*

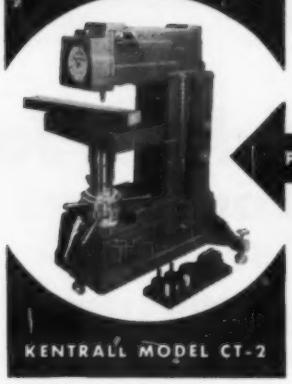
112. High-Temperature Alloy
14-page bulletin on Udimet 500 gives composition, heat treatment, machinability, hot working characteristics and properties. *Utica Metals Div.*

113. High-Temperature Alloy
Property data for 21% Cr, 9% Ni heat-resistant alloy. *Electro-Alloys*

114. High-Temperature Alloys
20-page booklet on nine alloys for elevated temperature service. Data sheets cover analysis, physical constants, mechanical properties, heat treatment, workability, machinability, welding, corrosion resistance. *Carpenter Steel*

(*Continued on page 48-A.*)

2 Applications (REGULAR AND SUPERFICIAL) 1 Tester



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The Kentrall cuts costs because it does the job of two conventional testers, requires only half the space and maintenance. Write for more detailed information, plus a list of prominent users who have switched to Kentrall. 7B148

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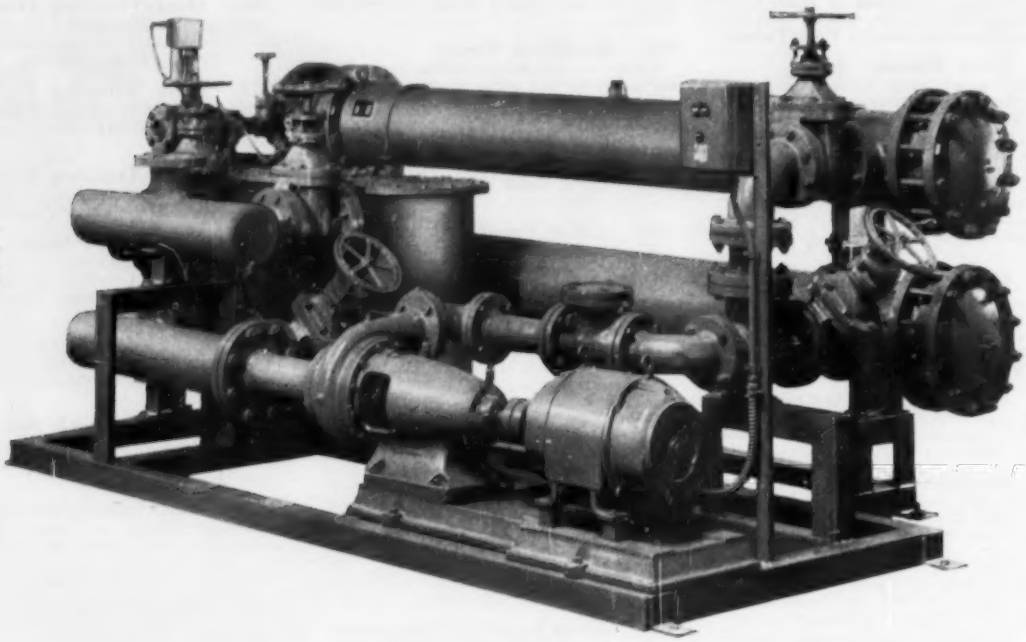

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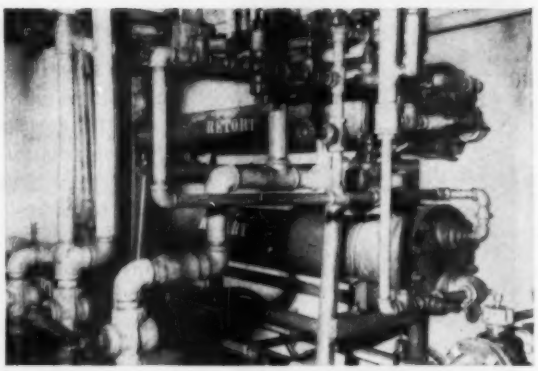
B&G Quenching Systems help you maintain uniform quality of heat-treated parts—cut substandard rejects—by accurately controlling the temperature of quenching oil.

For batch or continuous quenching, a job-tailored B&G Quenching System circulates oil at high velocity and turbulence through the quench tank; strains it, cools and recirculates it—and holds it at specified temperature throughout the quench period. Result: Uniform quality parts.

However large or small your heat-treating operation may be, B&G can furnish a self-contained, fully automatic quench oil cooling unit. It will arrive ready to go to work—your only responsibility is to connect to the quench tank and water lines. (The system is movable, too, in the event of layout changes.) Or, if you prefer, you can purchase the components and assemble them on the job. Either way, our engineering department's help is always available.

Write for this readable, informative combined Catalog and Selection Manual on B&G Self-Contained Oil Coolers.



B&G Controlled Oil Quenching System helps maintain uniform quality of heat treated parts in Chrysler Corporation Automatic Transmission Plant, Indianapolis, Indiana.

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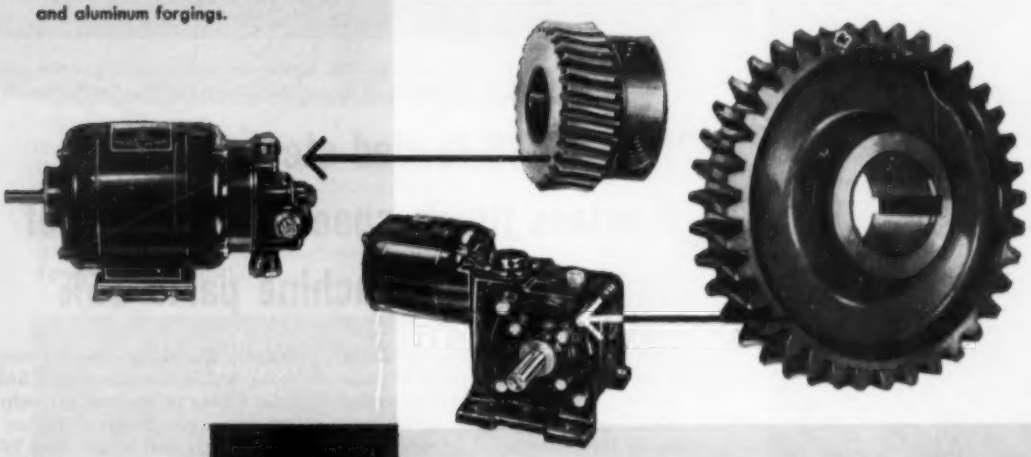
MUELLER BRASS CO. forged gears improve dependability and performance of BODINE electric motors

For combined high shear strength and maximum wear life in their single and double reduction speed reducer motors, Bodine Electric Company of Chicago uses gears forged from Mueller Brass Co. 603 Alloy.

Bodine has specified Mueller Brass Co. forged gear blanks because of their consistently high quality . . . there is no porosity, foreign inclusions or defects typical of cast blanks. The hot working of the metal followed by heat treatment to the desired physical properties produces a refined grain structure to give uniform machining and wear in service. The forged blanks are consistent in size and held to close tolerances. Bodine has also found that the excellent machinability of the blanks in the hobbing operation increases overall hob life.

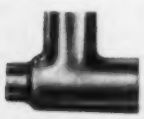
For forgings of high tensile strength, high density, minimum porosity, light weight, corrosion resistance, good machinability and low costs with little scrap loss, it pays to specify forgings from the Mueller Brass Co., the world's largest producer of brass, bronze and aluminum forgings.



only the man from Mueller Brass Co.

can offer unbiased advice on the "one best way" of producing your parts, because Mueller Brass Co. is the *only* fabricator in the country offering all these methods of production . . . assuring you the best product at the best price . . . made the one best way.

Write today for complete catalogs on any of these products.



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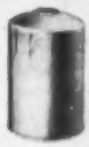


COLD-PREST IMPACT EXTRUSIONS

SCREW MACHINE PRODUCTS

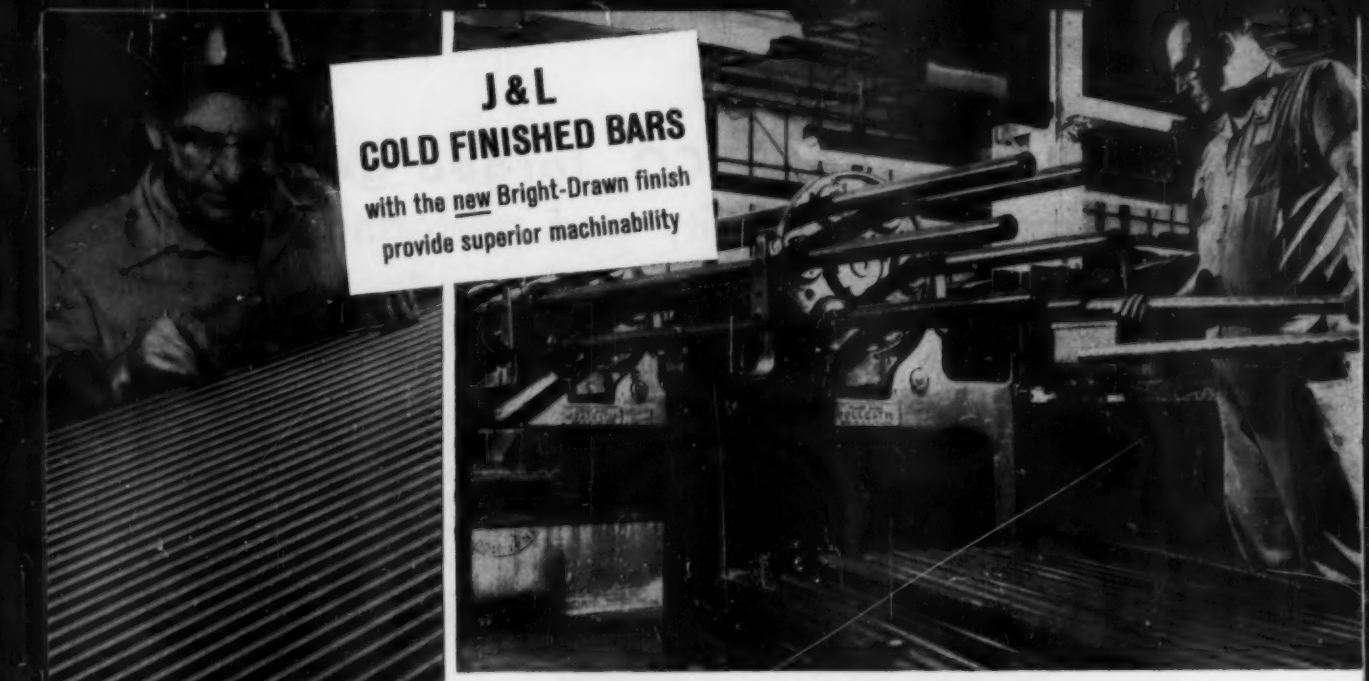
POWDER METAL PARTS

RED BRASS CASTINGS

Also producers of: Super Cutting Red Tip Brass Rod • Aluminum Extrusions Aluminum Sheet, Coil and Strip • Plastic Pipe and Fittings • Copper Tube and Solder Type Fittings •

MUELLER BRASS CO. PORT HURON 28, MICHIGAN

262



J&L's B-1113 leaded steel permits 35% higher machining speeds in this multiple spindle screw machine operation at Singer Manufacturing Co., Elizabethport, N. J.

"J&L B-1113 leaded steel provides flawless finish, speeds machining of Singer sewing machine parts 35%"

"Flawless finish of 'Slant-O-Matic' hook assembly components machined from J&L B-1113 leaded steels and carefully polished prevents thread snags," according to officials of Singer Manufacturing Company.

With the "Slant-O-Matic" hook assembly moving at 3200 revolutions a minute, the slightest burr or tool mark on any part would snag the thread. Singer officials report the machined surfaces with J&L steel are "definitely easier to polish." They are now using leaded steel in over 100 components on the scores of industrial and household machines they manufacture.

"Use of cold finished leaded steel bars also speeds production 35% on our multiple spindle screw machines. And we get 25% longer tool life," Singer officials report.

Similar machining qualities and speed are possible in your operations with J&L controlled quality cold finished steel bars. A J&L steel specialist can recommend exactly the right steel for any job from J&L's complete cold finished line. Chances are he can help you get improved finishes, higher cutting speeds and longer tool life.

Call your local distributor or write to Jones & Laughlin Steel Corporation, Dept. 405, 3 Gateway Center, Pittsburgh 30, Pa.

The superior surface finish on hook assembly components prevents thread snags. Parts are machined from J&L leaded steel bars with the improved new Bright-Drawn finish.

J&L STEEL

Jones & Laughlin Steel Corporation

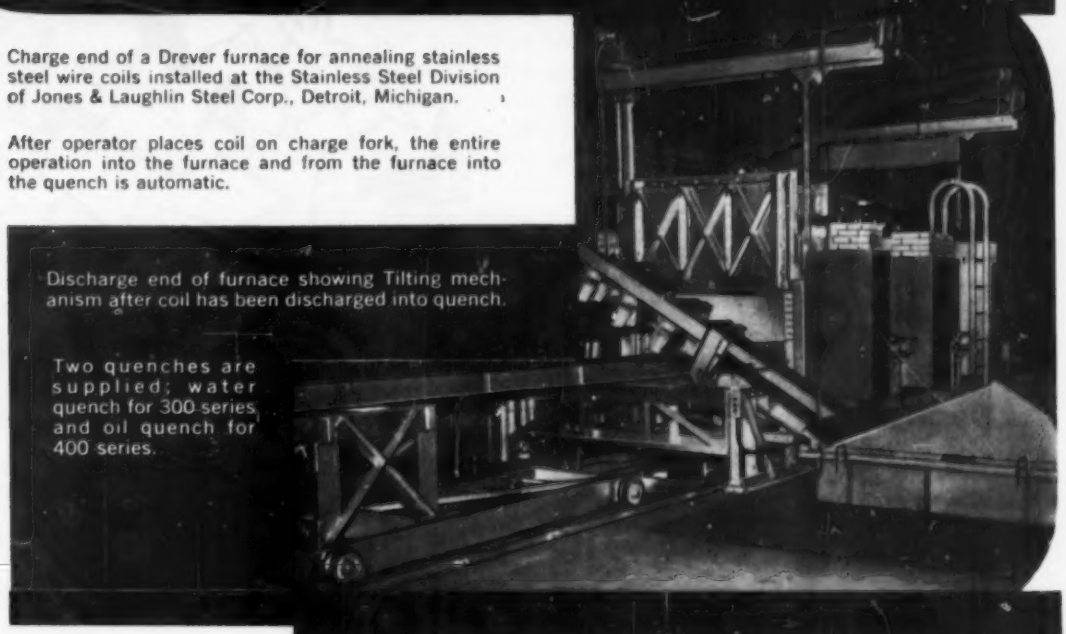
PITTSBURGH, PENNSYLVANIA

DREVER

Wire Coil Annealers

Charge end of a Drever furnace for annealing stainless steel wire coils installed at the Stainless Steel Division of Jones & Laughlin Steel Corp., Detroit, Michigan.

After operator places coil on charge fork, the entire operation into the furnace and from the furnace into the quench is automatic.



Discharge end of furnace showing Tilting mechanism after coil has been discharged into quench.

Two quenches are supplied; water quench for 300 series and oil quench for 400 series.

Drever's gas-fired coil annealing furnace is designed to handle (4) 250 lb. coils of wire per hour. Coils vary from 36" to 48" O.D. in size and from 200 to 250 lbs. in weight.

Uniform and rapid heating of coils is accomplished with a minimum of scale formation.

Consult Drever engineers on your stainless wire, rod, bar, sheet, plate and strip heating problems.

DREVER COMPANY

RED LION ROAD BETHAYRES, PA.

37

JANUARY—Bought anhydrous ammonia at bargain price on supplier's vague quality claims . . .

LATER—Moisture in furnace . . . discoloration of finished parts . . . pickling and polishing necessary . . .

STILL LATER—Oil! Pressure regulators clogged . . . dissociator catalyst poisoned . . . incomplete dissociation . . .

TOO LATE—Parts and profits in scrap pile . . . metal treating line down for replacements and repairs . . .

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ARMOUR AMMONIA DIVISION

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Quality ammonia from the most distribution points . . . 171 cylinder stock points, 12 bulk stations!

(Continued from page 43)

115. High-Temperature Alloys
New 12-page booklet on Hastelloy B, nickel base alloy. Composition, formability, tensile, rupture and creep data. Corrosion resistance. *Haynes Stellite*

116. High-Temperature Lubrication
Bulletin 423 on colloidal graphite and molybdenum disulfide dispersions and their use for high-temperature lubrication. Case histories. *Acheson Colloids*

117. High-Tensile Steel
12-page bulletin on properties and composition of N-A-X high-tensile steel. Examples of resistance to impact, fatigue, abrasion, corrosion. *Great Lakes Steel*

118. Hot Working Steels
10-page pamphlet on hot working steels. Composition, machining and inspection, heat treatment. Properties, applications. *Marathon Specialty Steels*

119. Impact Testing
Bulletin on machine for Izod, Charpy and tension testing. *Riehle*

120. Inconel
New 24-page Bulletin T-7 on properties of Inconel. 22 property tables. Corrosion resistance and working characteristics. *International Nickel*

121. Induction Heaters
8-page bulletin EH 57-6 on electronic induction heaters. Specifications, basic components, guide to brazing and soldering and frequency selection chart are included. *Magnethermic*

122. Induction Heating
8-page bulletin on high-frequency motor-generator sets for induction heating. *Ohio Crankshaft*

123. Induction Melting
Folder R-51 describes induction furnaces for galvanizing applications. *Ajax Engineering Corp.*

124. Inspection
12-page booklet on magnetic particle inspection. Equipment, uses, kinds of defects that can be found. *Magnaflux*

125. Inspection
Data on multi-frequency inspection of nonferrous and nonmagnetic metals. *Magnetic Analysis*

126. Isothermal Quenching
Bulletin dealing with isothermal treatment of carbon and alloy steel in molten salt baths. *Ajax Electric*

127. Laboratory Equipment
New bulletin on cutting test specimens describes methods for different types of metals. Price list. *Sieburg Industries*

128. Laboratory Equipment
New 32-page bulletin on complete line of laboratory balances, balance weights, and accessories. *Harshaw Scientific*

129. Laboratory Furnace
Data on nonmetallic resistor furnaces for research, testing or small-scale production. *Harrop Electric Furnace*

130. Laboratory Furnace
Data on laboratory and production vacuum furnaces. *General Vacuum Corp.*

131. Leaded Alloy Steel
8-page bulletin gives mechanical properties of Rycut 40, medium-carbon fast-machining leaded alloy steel. Case studies. *Ryerson*

132. Leaded Steels
16-page booklet on basic characteristics, mechanical properties and workability of leaded steels. Case histories. *Copperweld Steel Co.*

133. Lubricant
8-page booklet, "Biggest Ounce of Protection", tells of lubrication with colloidal graphite products. *Grafo Colloids*

134. Lubricants
Bulletin 581 on colloidal graphite dispersions for industry. 17 uses listed. Tables on concentrated and ready-to-use solutions. *Graphite Products Corp.*

135. Magnesium
53-page book on wrought forms of magnesium. Includes 44 tables. *White Metal Rolling & Stamping Corp.*

136. Metal Forming
Folder on rolling mills, swaging machines, wire shaping mills, wire and tube drawing machines. *Fenn Mfg.*

137. Metal Powders
Brochure on tungsten and molybdenum powders and granules, zirconium wafers and other refractory metal products. *Metals & Residues, Inc.*

138. Metal Marking
New bulletin on all purpose electric pen which will arc etch any metal. *Newage Industries*

139. Metal Melting
New chart showing melting points of metals in both Centigrade and Fahrenheit. *Fansteel Metallurgical Corp.*

140. Metal Parts
New Publication BG-5 on small precision metal parts. Describes and illustrates parts designed for low-cost production. *American Brass*

141. Metallograph
20-page booklet, E-232, on Balphot all-purpose metallograph—bright field, dark field, polarized light, phase contrast. *Bausch & Lomb*

142. Metals Processing
8-page brochure on equipment and facilities for precision cold rolling, forging, vacuum and air melting. *Precision Metals Div., Hamilton Watch*

143. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Torsion Balance*

144. Microscope
New Technical Bulletin HHS-2 on vacuum heating stage which permits specimens to be examined at temperatures ranging from room temperature to 2000° F. Application, specifications. *Unitron Instrument Div.*

145. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

146. Nonferrous Wire
Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

147. Nuclear Forgings
6-page brochure on carbon, alloy and stainless steel forgings for nuclear reactor applications. *U. S. Steel Corp.*

148. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

149. Oil Quenching
Catalog FB-1052-A on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett*

150. Phosphating
Free phosphating analysis kit to determine if products are adaptable to phosphating. *Turco Products*

151. Photomicrography
6-page folder on cameras for making photomicrographs. Description of six models. Illuminators and other accessories. *American Optical Co.*

152. Powder Metallurgy
Technical literature on high-density sintered metal parts. *Supermet Div., Globe Industries*

153. Powdered Iron
Properties of Plast/Iron with and without copper. *Plastic Metals Div.*

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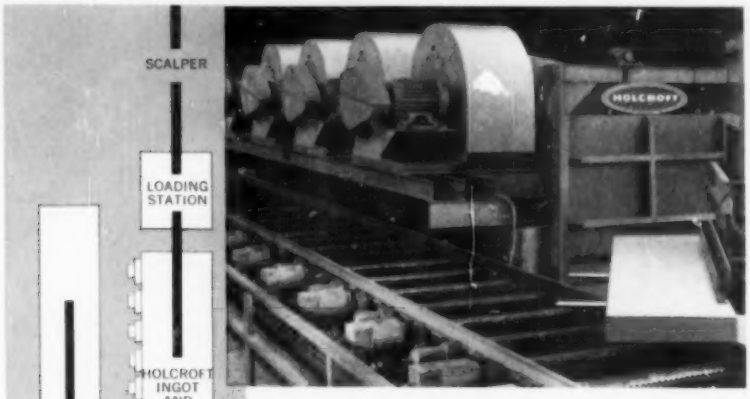

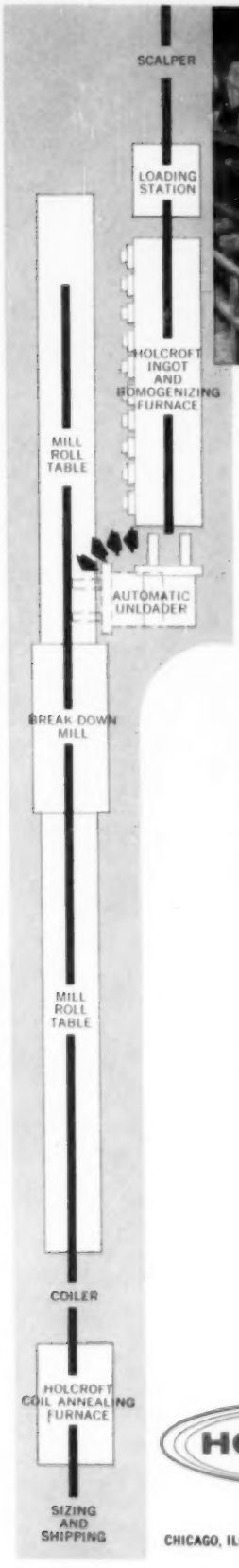

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from J&L STAINLESS and STRIP DIVISION

restricted and standard specification cold rolled strip steel

FULL LINE

Let's examine this "Full Line" product list of cold rolled strip steel. At J&L it includes all carbon grades, coated and uncoated, alloy, stainless and tempered spring steel. It offers all thicknesses from .001" or less to .156" or more, in widths from ¼" to 24"—and tolerances for gauge and width closer than standard when required. There are "Full Line" advantages, too, in a range of controlled tempers and structures possible only with the variety of annealing, heat treating and rolling processes found at J&L.

Your "Full Line" benefits can start by specifying J&L because only J&L makes standard and restricted specification cold rolled strip steel in such a wide range of analyses, grades and sizes to accurately meet the most exacting need.

For Strip Steel, call the Strip Steel Specialist—J&L.

J&L STAINLESS & STRIP DIVISION produces a full line of restricted and standard specification strip steel in these grades and types:

Low Carbon	Electrolytic Zinc
High Carbon	Alloy
Tempered Spring Steel	Stainless

STRIP J&L STEEL

Jones & Laughlin
STEEL CORPORATION
STAINLESS and STRIP DIVISION
YOUNGSTOWN 1, OHIO

154. Powdered Metals
24-page catalog 815 on 37 different models of powder metal presses. *Stokes*

155. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

156. Press Brake Dies
New 4-page bulletin describing roll form press brake die. *O'Neil-Irwin Mfg.*

157. Pyrometer
Catalog No. 100 on radiation pyrometers with ranges from 1000 to 3400° F. *Pyrometer Instrument Co.*

158. Quenching
New bulletin on automatic quenching machine for volume production. Features, advantages, operation. *Gleason Works*

159. Radiation Badges
Folder on film badges for monitoring exposure to radiation. *St. John X-Ray Laboratory*

160. Radiography
16-page booklet on materials and accessories for industrial radiography. Guide to selection of film. Recommended development techniques. *Eastman Kodak, X-Ray Div.*

161. Recording Charts
New Bulletin Y1906 on charts for special requirements, including pre-printed photo charts for oscillographic recording. Chart samples. *Bristol Co.*

162. Refractories
New technical data card, Bulletin R-52 on firebrick. Information on refractory maintenance and specifications. *Refractories Div., B. & W.*

163. Refractory Coating
Data on aluminum oxide and silicon carbide coating which may be sprayed on. *Norton Co.*

164. Rolling Mills
Data on 2-high/4-high combination rolling mill for metallurgical production and research. *Loma Machine Mfg. Co.*

165. Rust Prevention
Nine bulletins in one folder on rust prevention. Theory of corrosion. *Production Specialties*

166. Rust Prevention
Bulletin No. 51 on anionic surface active agent for oil-soluble rust and corrosion inhibitors, emulsifying, wetting and dispersing agents. *Sun Oil*

167. Saws
Catalog C-55 describes 35 models of metal-cutting saws. *Armstrong-Blum*

168. Silver Brazing
New Technical Bulletins T-1 and T-2 on silver brazing alloys. Compositions, melt and flow points of 32 alloys. *Handy & Harman*

169. Spectrometer
Newsletter, June, 1958, describes convertible Ebert spectrograph and gives gratings available. *Jarrell-Ash*

170. Spectrometer
8-page Bulletin 44 on direct reading spectrometers. Operation and construction. *Baird Atomic*

171. Stainless Castings
28-page booklet of data on stainless castings. Analyses, properties, handling and heat treatment. Typical applications. *Allegheny Ludlum Steel*

172. Stainless Fastenings
20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fittings and specialties. *Star Stainless Screw*

173. Stainless Steel
Pocket card gives instructions for making a simple chemical spot test to distinguish 200 series from 300 series stainless steels. *Electro Metallurgical Co.*

174. Stainless Steel
12-page bulletin on chromium-manganese austenitic steel. Effect of cold working, properties at elevated temperatures, corrosion resistance, magnetic permeability. *U.S. Steel Corp.*

175. Steel Bars
Wall chart lists 241 AISI grades of cold finished steel bars and gives their analysis. *LaSalle Steel*

176. Steelmaking
24-page booklet on melting, forging, heat treating, machining and other facilities. Type of products produced. *Midvale-Heppenstall Co.*

177. Temperature Control
New 4-page folder on application of temperature controls in metal finishing operations. Range −30 to 1100° F. *Partlow Corp.*

178. Test Cabinets
Data on corrosion test cabinet for salt spray testing. *G. S. Equipment Co.*

179. Thermocouple Parts
New Bulletin E on thermocouples, thermowells, connection heads and fittings. Types and alloys. *Thermo Electric*

180. Thermocouple Supplies
New Bulletin No. 300-56 on complete line of thermocouple insulators. Dimensions, sizes, types. *Claud S. Gordon*

181. Thermocouple Wire
Bulletin No. 2 on platinum, platinum-10% rhodium, platinum-13% rhodium wires gives physical and electrical properties. *J. Bishop & Co.*

182. Thickness Gage
Folder on pocket-size gage. How to use it. *Ferro Corp.*

183. Tool Steel
New 4-page data sheet on free machining air-hardening die steel gives physical and mechanical test data, forging, annealing, tempering information. *Allegheny Ludlum Steel*

184. Tool Steel
4-page bulletin on Ry-alloy, oil-hardening tool steel. Applications, advantages, heat treatment and forging practice. *Ryerson*

185. Tool Steel
New reference chart listing brand names of 13 tool steel suppliers. SAE and AISI classification numbers. *Uddeholm*

186. Tubing
Data Memorandum No. 7 on beryllium-copper tubing. Mechanical and physical properties. Application, corrosion resistance, heat treatment and fabrication. *Superior Tube*

187. Ultrasonics
Data sheets on high-power ultrasonic generators for mass production, and ultrasonic scrubber. *Acoustica Associates*

188. Welding
New 12-page Pamphlet 2004 Ea on automatic flash welding machines. Advantages, applications. *ASEA Electric, Inc.*

189. Welding Fittings
New Technical Bulletin FDC-257 on welding fittings and flanges. Size, dimensional and physical data. *Welding Fittings Dept., B. & W. Co.*

190. Welding Stainless
12-page booklet—a guide to better welding of stainless steels. In question and answer form. *Arcos*

191. Welding Titanium
New 8-page technical brochure on the arc welding of titanium. Lists grades of pure titanium and titanium alloys which can be welded. Basic problems discussed. *Mallory-Sharon Metals*

192. Wire Mesh Bolts
130-page reference manual on mesh specifications, design, metallurgical data. *Cambridge Wire Cloth*

193. Wires
New booklet describing physical and chemical properties of cold drawn fine wires. Applications. *Parts Div., Sylvania*

January, 1959

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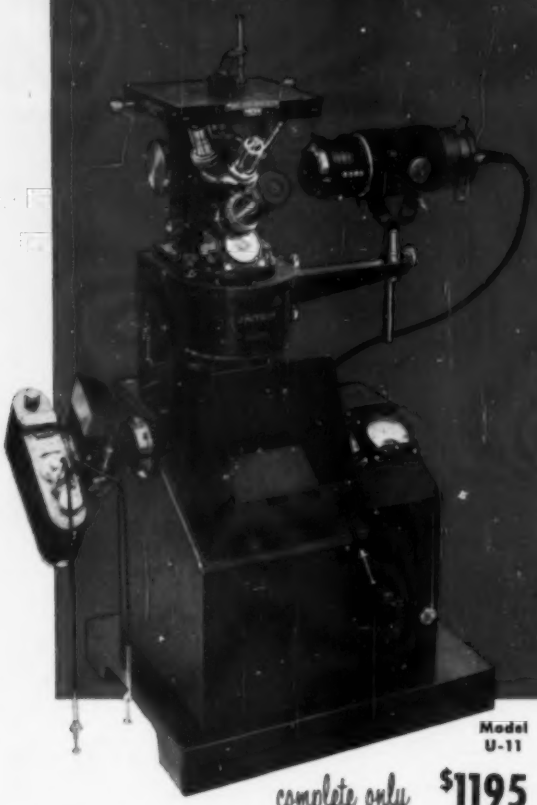
GOODYEAR ATOMIC — UNIV. OF CINCINNATI
NATIONAL CASH REGISTER — UNIV. OF WASHINGTON
U. S. STEEL — GENERAL ELECTRIC — R. C. A.



Model U-11

complete only $1195

BINOCULAR MODEL only $1379

UNITRON METALLOGRAPH and Universal Camera Microscope, Model U-11: A completely self-contained instrument of modern design for visual observation, photography, projection and measurement of both opaque and transparent specimens, using bright-field, dark-field or polarized illumination. While compact in size, it duplicates the performance of large, cumbersome instruments. Even laboratories on a limited budget can enjoy the accuracy, speed and efficiency possible only with a complete installation of this type.

- Standard optics include 5 parfocal objective lenses with revolving nosepiece, 4 photographic eyepieces on a revolving turret, 3 visual eyepieces, all coated. Magnification range: 25-2000X.
- High-intensity illuminator with variable transformer built into the microscope base.
- Built-in 3¼" x 4¼" camera. The image is automatically in focus in the camera and transition from observation to photography is instantaneous.
- Calibrated square mechanical stage with calibrated rotatable stage plate.
- Calibrated polarizing apparatus, transmitted-light accessories for transparent specimens, filters, micrometer eyepieces, film holders, cabinets, dustcovers, etc. all included.
- Additional accessories, available at extra cost include: Polaroid Land Camera attachment for "60-second" photography; 35mm camera attachment; low power (5-40X) objectives; vacuum heating stage for temperatures to 1100°C.

Model MEC

complete only $399

BINOCULAR MODEL only $599

UNITRON INVERTED Metallurgical Microscope, Model MEC: Many of the features of the UNITRON Metallograph U-11, which are connected with visual observation of opaque specimens, are included in this compact unit. Think of the time which can be saved in your laboratory by providing each metallurgist with one of these handy, inexpensive units for use at his desk. Model MEC is also ideal for use together with a polisher or microhardness tester.

- Standard optics include 4 parfocal objective lenses: 5X, 10X, 40X, 100X oil immersion on revolving nosepiece; 3 eyepieces: P5X, Micrometer 10X, Ke15X, all coated. Magnification range 25-1500X.
- Vertical illuminator with iris diaphragm. Transformer housed in microscope base. A microswitch on the base provides an extra high intensity for photography.
- Binocular model has provision for attaching 35mm camera to microscope base. A 35mm camera attachment is available to attach to the eyepiece tube of the monocular model.
- Calibrated square mechanical stage with calibrated rotatable stage plate.
- Calibrated polarizing apparatus, 5 filters, dustcover, cabinet, etc. all included.
- Additional accessories available at extra cost include: 35mm camera attachment; K20X eyepiece for 2000X; transmitted-light accessories for transparent specimens; vacuum heating stage.

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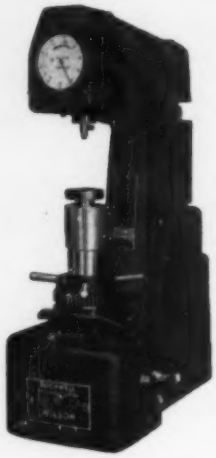

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Semi-Automatic (manual feed) and Fully Automatic—for automatically classifying tested pieces as CORRECT, TOO HARD, or TOO SOFT—at test rates up to 1000 pieces per hour.

Special Machines—for testing large objects, obtaining internal readings, and other unusual applications.

ALL WILSON "ROCKWELL" hardness testers provide these advantages:

Accurate performance—precision built, with exact calibration, for consistently correct results.

Long life—durable as a machine tool.

Easy operation—even an unskilled operator can get perfect readings. All controls conveniently grouped.

Easy maintenance—interchangeable mechanisms, with spindles mounted on oil-less bearings.

DIAMOND "BRALE" PENETRATORS ... perfect testing every time

A perfect diamond penetrator is essential to accurate hardness testing. Since one point of hardness on the "ROCKWELL" scale represents only 80 millionths of an inch penetration—only 40 millionths on a Superficial tester—the slightest imperfection will cause a false reading.

Only *perfect* Wilson Diamond Brale Penetrators are sold. Each diamond is flawless, with no chips or cracks. It's cut to an exact shape. Microscopic inspection of every diamond—one at a time—assures this perfection—and assures you of accurate hardness testing every time.

TUKON TESTER ... for precision MICRO & MACRO testing

The TUKON Tester measures extremely shallow indentations. It's used, for instance, by manufacturers of watches, hairsprings, needles, and fine wire. Laboratories use the TUKON for tests on individual crystals or particles of microscopic size. Producers of coatings, film, ceramics, and many other materials have made good use of the TUKON.

Three models are available to meet your individual requirements. TUKON Testers use both the Knoop and 136° Diamond Pyramid Indenter. Each TUKON Tester is a self-contained hardness testing instrument— no accessory equipment is needed. Knife edges and levers of fixed length are used throughout for application of exact load and freedom from internal friction.

A COMPLETE LIBRARY of helpful information

A wide variety of bulletins describes the many instruments, accessories, and services Wilson offers. Write for your choice:

DH-325 — WILSON "ROCKWELL" Hardness Testers • **DH-326** — "ROCKWELL" Superficial Hardness Testers • **DH-327** — Special "ROCKWELL" Testers, including Automatic and Semi-Automatic models • **DH-7** — TUKON Applications • **DH-328** — TUKON Testers.

ACCO **WILSON**

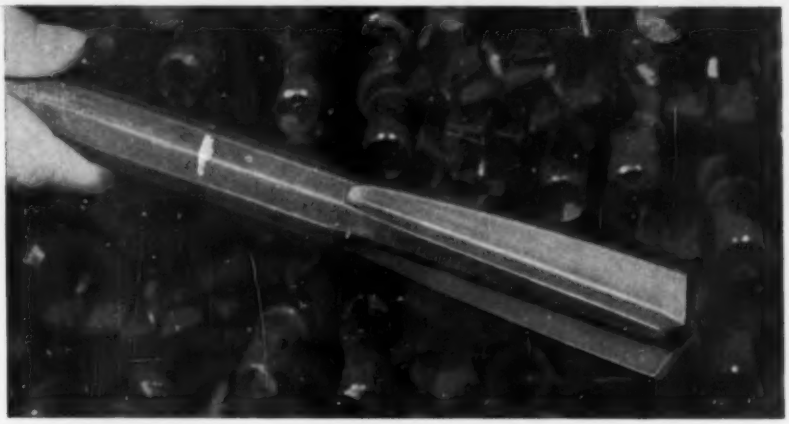
MECHANICAL INSTRUMENT DIVISION

AMERICAN CHAIN & CABLE

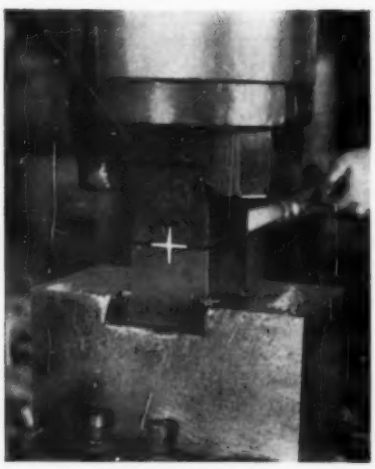
230-F Park Avenue, New York 17, N.Y.

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.



57 HW tool steel forges star drills while they're red hot



In the Hampstead, Md., plant of Black & Decker Manufacturing Co., they needed a hot-work tool steel for use in the hot forging of star drills. The drills were to be made from 7/8-in. carbon steel. The tool steel for the forging dies had to be easy to machine, have good resistance to wash, and stay on the job for long periods.

Several competitive tool steels were tried, but their major shortcoming was insufficient resistance to wash in critical areas of the die. Then Bethlehem 57 HW was used because of its high tungsten content, which leads to excellent resistance to wash and wear.

After the 57 HW die had been in service for some time, we learned that it had given a good account of itself in this application. The die had been hardened to approximately Rockwell C46. It was extremely economical because of the way it stayed on the job.

Once again a Bethlehem tool steel had provided outstanding service in the field.

57 HW (AISI H-21) is our 9 pct tungsten type of hot-work tool steel. Air-hardened, it has high red-hardness and high abrasion-resistance. It also has good resistance to heat-checking, and can take plenty of shock.

Typical Analysis

Carbon	0.35	Tungsten	9.35
Chromium	3.25	Vanadium	0.50

57 HW has been proved in many hot-work applications. But don't take our word for it. Give it a trial in your shop. You'll find your Bethlehem tool steel distributor at your service.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Brake Die Steel Can Be Flame Hardened

Brake Die tool steel bars are furnished in the heat-treated condition (squares and flats Brinell 248/293, and rounds 302/352) so that the customer merely has to machine the tool to the dimensions desired. For many types of metal forming operations, Brake Die steel does an excellent job. On some operations, however, certain areas of the dies may wear away faster than others. A common cure for this trouble is to use small inserts of BTR, our standard manganese oil-hardening tool steel, hardened to Rockwell C58-60 at the wear points.

A more economical way to solve this problem is to locally flame-harden the Brake Die steel at the wear points. Small surface areas on tools made of Brake Die steel can be hardened by merely heating with an oxy-acetylene torch for a few seconds (long enough to heat the surface to a definite red color, approximately 1500F). No quenching is required. The portion of the steel which is heated will harden to Rockwell C55-60 because of the rapid cooling produced by the conduction of heat from the small heated spot into the larger adjacent areas which have not been heated.

Flame hardening is not ordinarily considered for hardening tools, but here is the exception which proves the rule.

Why They Go for A-H5

In this shop, they wanted to combine long wear and minimum distortion on various types of trimming and blanking dies. They chose A-H5 (SAE A-2), and it did everything expected of it, and then some. A-H5 is our medium alloy air-hardening grade, with 5 pct chromium. It holds a keen cutting edge, has good resistance to abrasion and wear, and good deep-hardening properties. It's also easy to machine, as indicated above.

No. 1950

ULTRASONIC CLEANER FOR METALLOGRAPHY

No. 1952 Positioning Clamp and Automet Holder

This new scientific development is ideal for cleaning metallographic specimens. It removes the hazard of carrying abrasive particles from a coarse grinding stage on to a finer grinding stage. The cleaning is accomplished quickly, thoroughly and at low operating cost. No skill is required. Additional speed and convenience is achieved by using an additional Transducer Beaker. The positioning clamp is required to accommodate the specimen holder from the Buehler Automet automatic polishing attachment.

No. 1950 ULTRASONIC CLEANER . . $495.00
No. 1951 EXTRA TRANSDUCER BEAKER . . . $130.00
No. 1952 POSITIONING CLAMP for Automet Holder . . . . . $ 22.00

Buehler Ltd.

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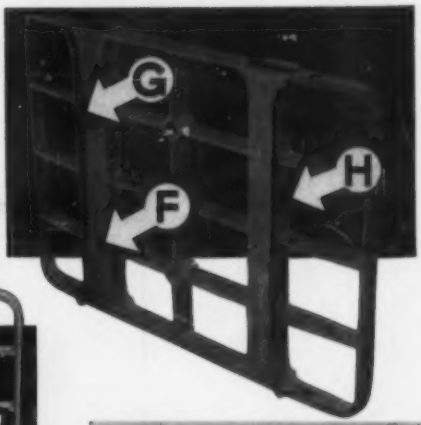

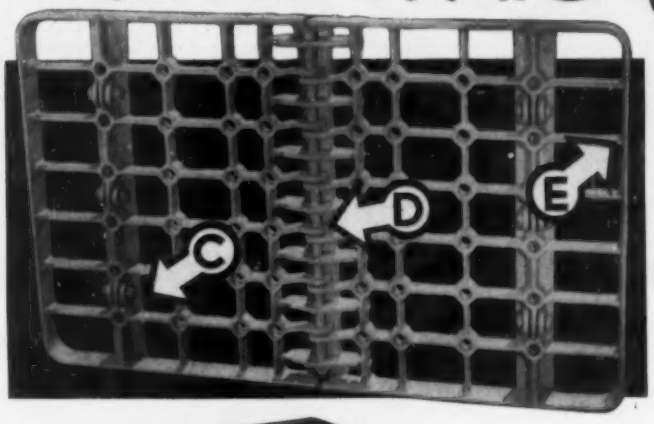

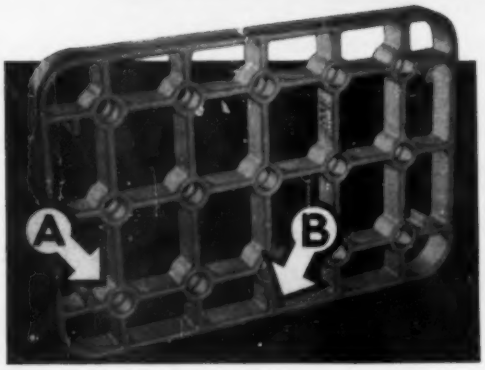

Why DO AECCo. TRAYS CONSISTENTLY GIVE BETTER SERVICE?

A UNIFORM SECTIONS AND BARREL CORES AT INTERNAL INTERSECTIONS — BETTER CASTINGS AND LESS THERMAL STRESS IN USE.

B CONTROLLED FINE GRAIN STRUCTURE AT EXTERNAL INTERSECTIONS—BETTER FATIGUE LIFE ASSURED.

C SHOES PROVIDED FOR RAIL SUPPORTS AS REQUIRED.

D AECCo. PROPRIETARY HINGE DESIGN FOR EQUAL LOADING ON THREE RAIL FURNACE APPLICATIONS.

E FULL RADII EVERYWHERE—NO SHARP CORNERS TO ACT AS NOTCHES FOR FATIGUE FAILURES.

F TUBULAR COMPRESSION MEMBERS AND RAIL SUPPORTS—FOR INCREASED STIFFNESS, AND STRENGTH WHERE STRENGTH IS NEEDED.

G INTEGRAL FLANGE ON TUBE SERVES AS RAIL GUIDE.

H GENEROUS OPENINGS FOR ATMOSPHERE AND QUENCH CIRCULATION CONTRIBUTE TO LONGER LIFE.

Because OF BALANCED DESIGN—ATTENTION TO DETAIL — PROPRIETARY PROCESSES and PRODUCTION KNOW-HOW

FURNACE TRAYS—of all types, sizes, and configurations—are an AECCo. specialty. We treat each tray design and order as an opportunity to apply our experience and knowledge in heat resistant alloys, and to create better HIGH TEMPERATURE TOOLING for the user.

SERVICE RECORDS—in the plants of many customers—confirm that AECCo. furnace trays do a better job and last longer. Note Accoloy Pointers for a few of the details which contribute to these results.

HEAT RESISTANT CASTINGS
ACCOLOY
STAINLESS STEEL CASTINGS

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1700 W. WASHINGTON ST., CHAMPAIGN, ILL.
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ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

die blocks

For the production of ferrous and non-ferrous forgings in drop hammers, forging presses, and forging machines, we supply five types of pre-hardened, ready-to-use die blocks, inserts, and tools in SPECIAL MACHINING QUALITY that is commercially machinable *as hard as 477 BHN* with modern, high-speed or carbon tools.

FX—die blocks, inserts and tools for an unusually wide variety of hot work applications, both ferrous and non-ferrous, where reasonable first cost and large volume production is important.

DURODI—die blocks, inserts and tools for a wide variety of closed die-forgings made on forging presses, hammers and machines, involving unusual heat and abrasion problems.

CUPRODIE—die blocks for drop hammer and forging press applications, especially for light and medium weight forgings where long runs and high resistance to heat and abrasion are required.

SHELLEX—die blocks, inserts and tools for long run, close tolerance applications on forging presses, hammers and machines, requiring resistance to impact, shock, and sudden temperature change.

W4X—Inserts, tools and die blocks for close tolerance, long production runs of extrusion and forging presses, forging machines, and hammers.

forgings

"Forgings by Finkl" is synonomous with highest quality because our chromium-nickel-molybdenum heavy-duty forgings have the strength, stamina, and fatigue resistance to withstand the severe stresses and torsional strains encountered in modern heavy-duty machinery.

In addition to our CNM forgings, we are able to furnish forged products of AISI carbon and alloy steels, or many special analyses in the smooth forged, rough- or finish-machined condition.

Among the many specialties we have produced from our MO-LYB-DIE processed alloys are:

- Repair parts for all types of forging equipment
- Containers, liners, and plungers for extrusion presses
- Crankshafts for trimming presses, punch presses, mechanical forming presses, nail machines, engines, and pumps
- Gear and pinion shafts
- Plastic mold, and die casting die blocks
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Finkl is one of the few heavy forge plants in the United States to operate its own electric melt shop. This modern, fully equipped shop makes possible not only better control of steel quality, but also more precise production planning of all operations. Since each heat is melted and processed to meet a specific order or application, we can give individual attention to the particular requirements of each customer, thus assuring the best forging for your job.

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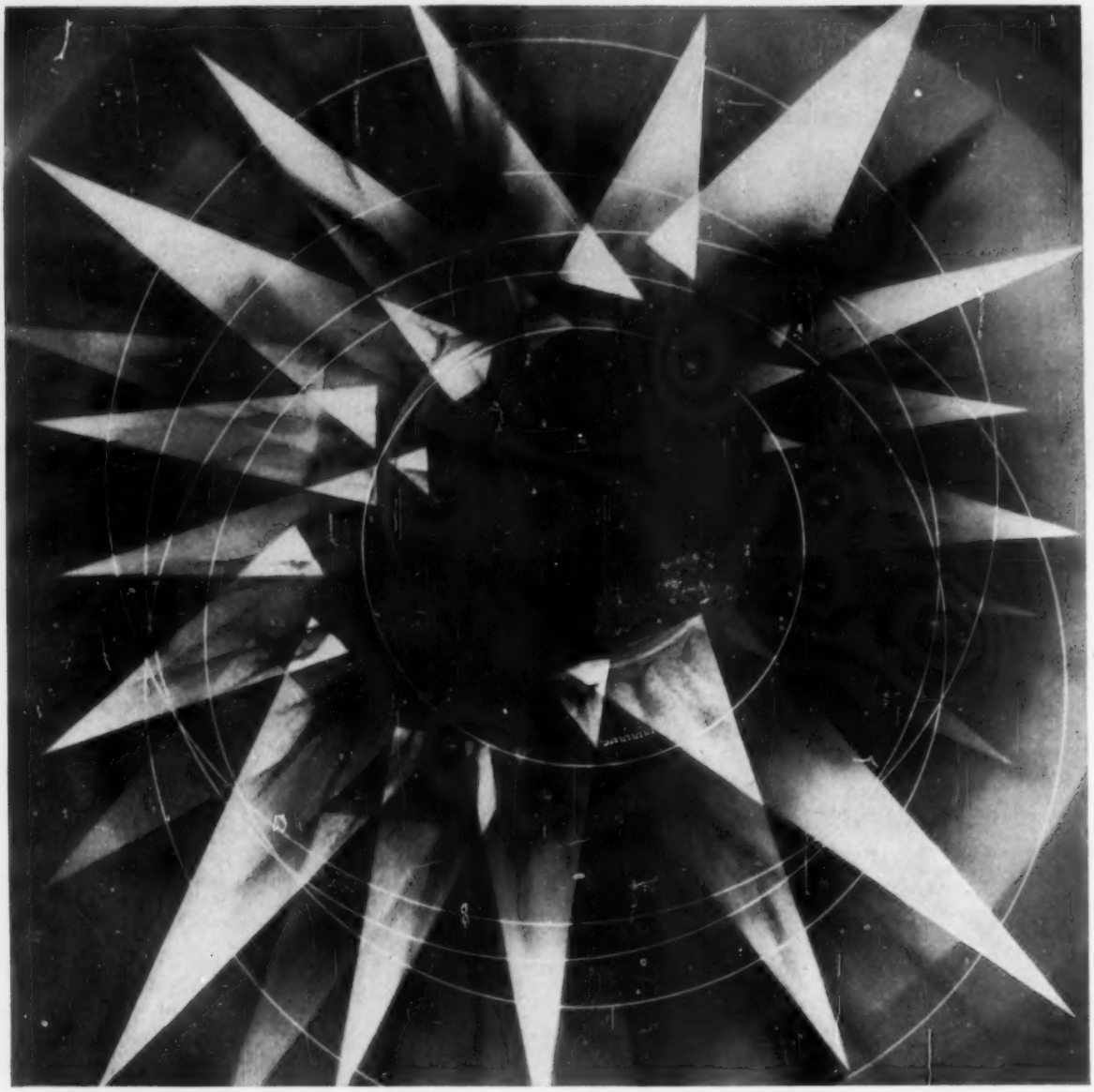

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- Increased ductility
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- Precise chemical control
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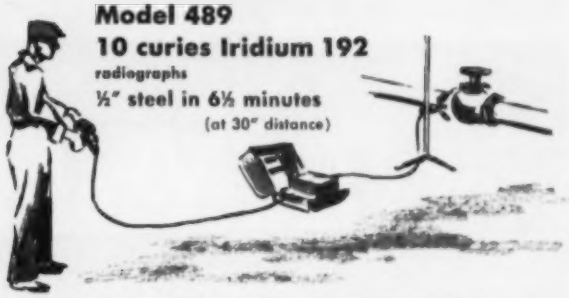

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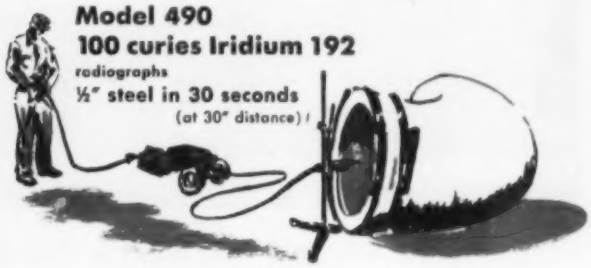
All this for only $1575.00 complete (without source).

P.S. It will also handle a 50 curie Thulium 170 source if you're inspecting light metals.



Here's a mobile powerhouse—a free wheeling isotope radiography unit that can easily handle the heavy stuff. 100 curies of Iridium 192 (55 RHM output) will radiograph, in one shot, the full girth weld of a 1½" thick steel pipe eight feet in diameter in 6½ minutes.

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For details on these units or any of the other machines or services listed below call any Picker Branch Office (see local 'phone book) or write Picker X-Ray Corp, 25 So. Broadway, White Plains, N.Y.

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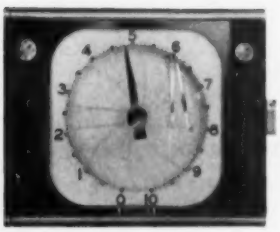
one stop for everything in industrial radiography

- portable x-ray units—130 KV, 140 KV, 160 KV, 200 KV, 260 KV
- x-ray units—35 KV Beryllium window, 90 KV, 150 KV (stationary and mobile), 270 KV portable, intensified image fluoroscopes
- units for isotope radiography—sources, equipment, containers for Iridium ^{192} Cobalt ^{60} Thulium ^{170} and Cesium ^{137}
- . . . films, tanks, darkroom sundries illuminators, *everything*

Bristol's 7-point coast-to-coast field service

Helps you from the time you start thinking instruments —through installation —for as long as the job requires



A Bristol Field Engineer is the man to call when you first start thinking about instrumentation. Located in a nearby Bristol office (they blanket the U.S. and Canada) he calls at your plant to assist you in planning your proposed installation. No obligation.

Application Engineers, specialists in the abilities and limitations of every type of instrument, and Process Specialists, experts in instrumentation techniques in varied fields can be called in where necessary. They insure you the right instrument, installation and operation for your specific job.

Service Engineers to keep your instruments operating perfectly are "on call" often within a few hours. They install, check and adjust instruments in your plant.

Periodic Check-up Service at regular intervals is also available.

Bristol's Instrumentation Schools for customer engineers help train your own technicians in instrument operation and maintenance.

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Fast Parts Service is assured by the Bristol practice of stocking service parts that may be needed in emergencies in all 38 Branch offices. You get fast action from a near-by source.

These big extras you get with Bristol instruments are good reasons—over and above outstanding basic instrument quality—why every Bristol installation gives such high accuracy and precision performance over an extremely long service life. To find out more about Bristol instruments or service, write: The Bristol Company, 106 Bristol Road, Waterbury 20, Conn. B.17

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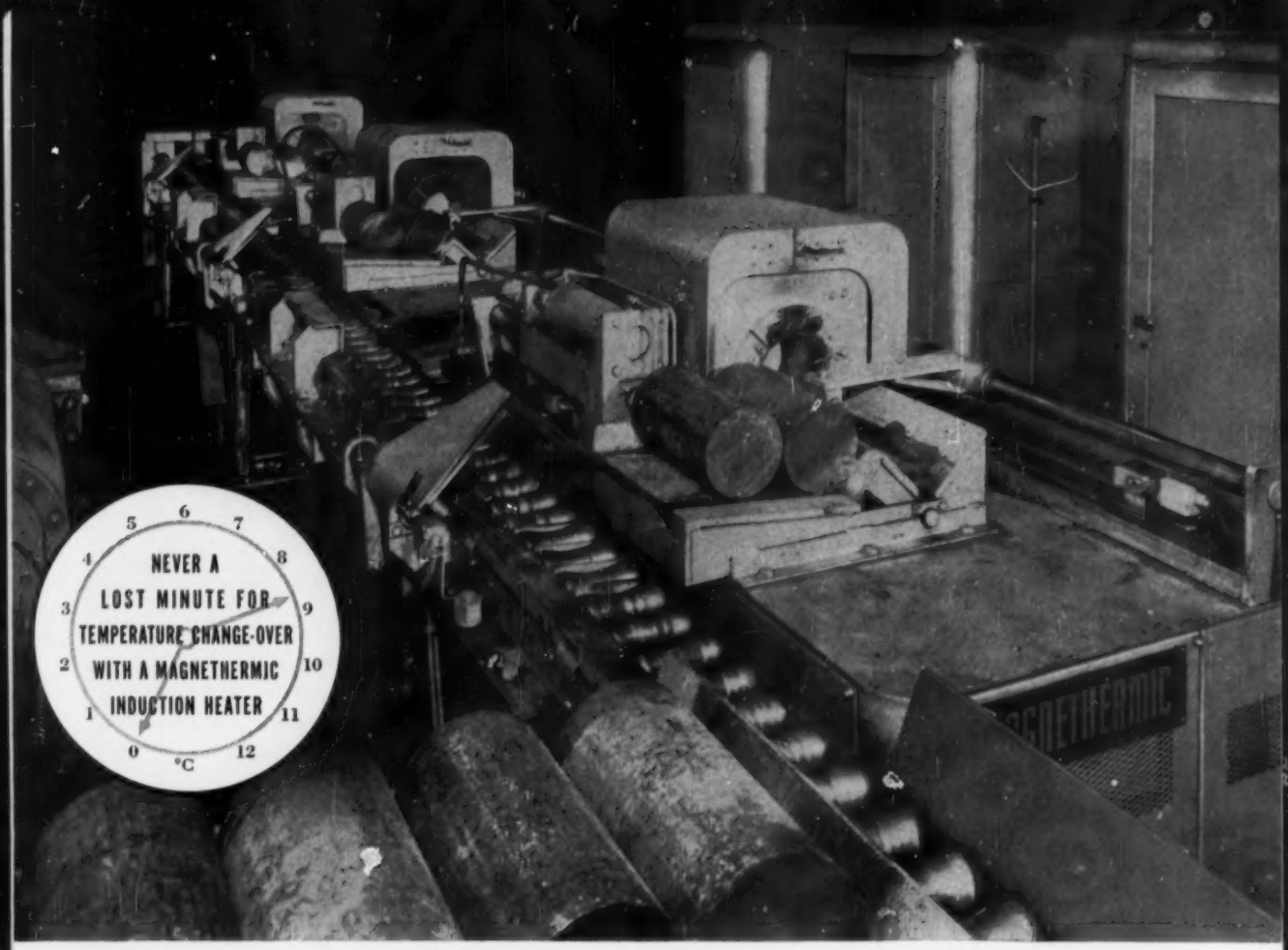

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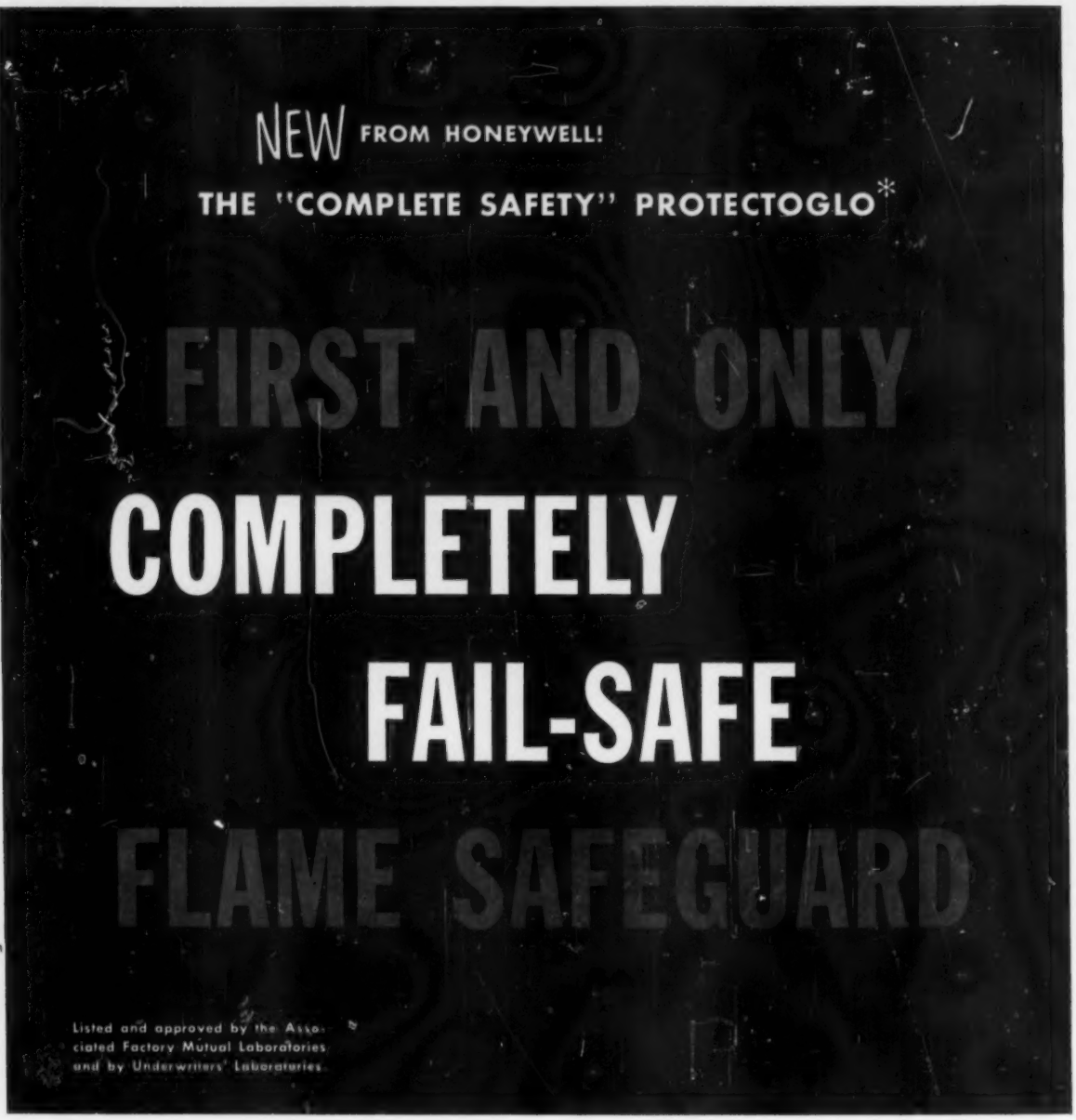

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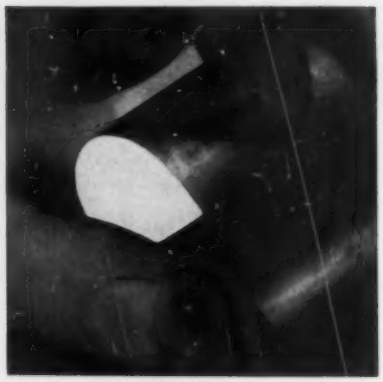

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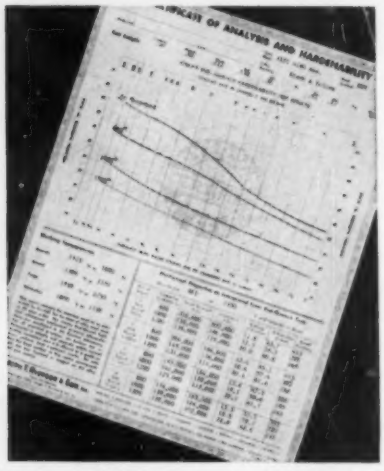

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Steelmaking Progress in Belgium and Luxemburg

*By A. DECKER**

Such interesting results were obtained with the experimental low-shaft blast furnace that a large furnace has been operating economically on fine coke with 15% moisture. The new OCP steelmaking process injects a mixture of oxygen and lime powder through the mouth of a standard 30-ton basic converter. Slag is poured off after about 14 min. when carbon is down to 0.7%. The afterblow is timed by stop watch. Excellent steel and agricultural slag result. (D8n, D10; CI-a, ST)

THE PROBLEM in a brief review such as this is one of selection from the large mass of available data presented at the International Iron and Steel Meeting held in Belgium the latter part of June.† Some 1250 specialists attended, coming from 30 countries. The scope of the proceedings may be judged from the topics of the various technical sessions:

Bottom-blowing in converter steelmaking
Steelmaking with pure oxygen
The basic openhearth
Large-capacity electric arc furnaces
The low-shaft blast furnace
New processes for direct reduction of iron ore
Modern techniques used in the blast furnace
Preparation of the burden
Theory and experimental equipment for the continuous casting of steel
Industrial experience in continuous casting of steel

A few will now be recounted in some detail.

*Head of Research in Process Metallurgy, Centre National de Recherches Métallurgiques (C.N.R.M.), Liège, Belgium.

†Proceedings published by C.N.R.M. at 530 Belgian francs.

Low-Shaft Blast Furnace

This experimental program started in 1953 and should be fairly familiar to readers of *Metal Progress,* since the plant and its early operations were described in the January 1955 issue, and there have been several briefer notices since then. The aim of the effort is to discover whether this device, so different from the traditional shaft furnace, can produce first-quality pig iron from low-grade fuels and ores. One quarter of the expense is borne by the Steel Research Institute of France (IRSID), one quarter by the Institute for Promotion of Scientific Research in Industry and Agriculture of Belgium (IRSIA) and the remainder by the European Coal and Steel Community.

Results to date were summarized in a comprehensive report by M. Malcor, president of IRSID, before the international meeting in June. The conclusion is that enough experience has already been acquired to prove that the low-shaft furnace can produce regularly basic bessemer pig iron from fine ores and low-quality fuels.

The first campaign made with small-sized metallurgical coke (0.5 to 1.25 in.) revealed immediately that a low-silicon iron (less than 1%) could be obtained from poor ore of the same size. It showed moreover that the top gas temperature did not exceed 200° C. whether the blast was enriched with oxygen or not.

In early runs the low-shaft furnace was blown with normal air, later with air enriched to 28% oxygen, while keeping a combustion rate at about 60 short tons of coke per day for a 32-sq. ft. oval hearth. Other things being equal, oxygen-enriched blast facilitated the working and considerably reduced the flue dust. On the other hand, it sensibly decreased the carbon content of the iron.

The ores used were exclusively phosphorus ores from Luxemburg or Lorraine — a siliceous ore containing 28.5% Fe, two calcareous ores containing 34.5 and 31.5% Fe, with a self-fluxing ore with 30% Fe. The humidity in these ores was around 10 to 12%.

At combustion rates under 50 tons per day, it was found that up to 60% of the burden could be fines under 10 mm. (0.40 in.) without a large increase in the production of flue dust. Another important conclusion was that the carbon content in pig iron increases when the size of the coke decreases, a 0.40 to 1.0-in. coke giving the normal 3.5% carbon.

After a few months working with small size coke, nothing but a semicoke was used (0.75 in. and finer) in several campaigns with normal air and oxygen-enriched blast. Fuel consumption ranged up to 78 tons per 24 hr. In these trials the general behavior of the furnace and the quality of the products were unchanged. The cokes in the earlier runs contained 10 to 20% moisture, 2% volatile matter, 11 to 15% ash; the semicoke contained about 15% moisture, 10% volatile matter and 12% ash.

Later on we experimented with bituminous coals, and the quality of the pig iron was comparable with that of the previous campaigns. However, the fuel consumption was specially high, leading practically to the place where the furnace became a gas producer.

In 1957, we made several runs where the charge contained pellets of fine ores obtained by a vacuum extrusion process. The only binder used was 3 to 4% water, so the extruded finished product contained about 15% moisture. The diameter of these extruded cylinders was reduced from 1.30 to 1.0 in., then to 0.60 in. with sensible improvement in working of the furnace and in coke consumption.

An economic survey of the costs for labor, fuel, ore, depreciation and gas production indicates that the low-shaft blast furnace will not revolutionize the operating conditions of the major iron and steel industries. This is essentially due to the low capacity of the production units, which greatly increases the final cost of pig iron.

This handicap may certainly be counterbalanced when ore fines, small coke or bituminous coal are available at a low price. Again, if merely 200 or 300 tons per day of iron can be marketed, the low-shaft furnace may be used to good advantage. This is why the countries with embryonic steel industries rightly consider the low-shaft blast furnace with interest.

From the beginning of the present year (1958), the low-shaft furnace has been worked only as a small experimental blast furnace, studying the effect of variations in top pressure, blast humidity, oxygen enrichment and fuel injections.

One finding of importance may be mentioned: By using a top pressure of 20 psi., the coke consumption was reduced to 300 lb. per ton.

Fine Coke in Blast Furnaces

Indications from the above campaigns in the low-shaft furnace indicated that a standard furnace could be operated with a burden of finer sizes (and consequently more homogeneous). It was expected that this would reduce top pressures and increase carbon in the pig iron without increasing the amount of coke. To prove these conclusions, Cockerill-Ougrée ran one of their furnaces with small coke (0.75 to 1.5 in.) with 15% moisture rather than the regular 3-in. metallurgical coke with 3% moisture. Not only was the coke in small sizes but the ore and sinter in the burden were fines through 2-in. and 1.4-in. screens, respectively. The furnace had a 12.5-ft. diameter hearth, was 50 ft. high above tuyeres, and had an effective capacity of 11,000 cu.ft. First results were presented to the international meeting by A. Firket, chief metallurgist (blast furnaces) of S. A. Cockerill-Ougrée.

Top temperature during this campaign was about 80° C. in comparison with 180° C. in ordinary operations. Of this 100° drop, 60° is due to the heat required to evaporate the water in the fine charge. Simultaneously, the normal production of flue dust (240 lb. per ton of pig

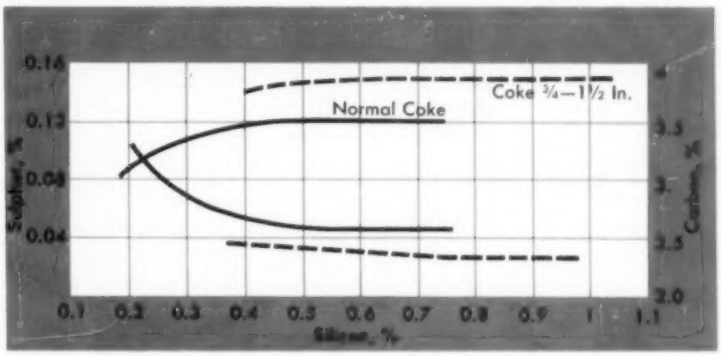


Fig. 1 — Carbon and Sulphur Content of Pig Iron for Normal and Small-Sized Coke at Different Silicon Contents. Top curves are for carbon; lower curves for sulphur

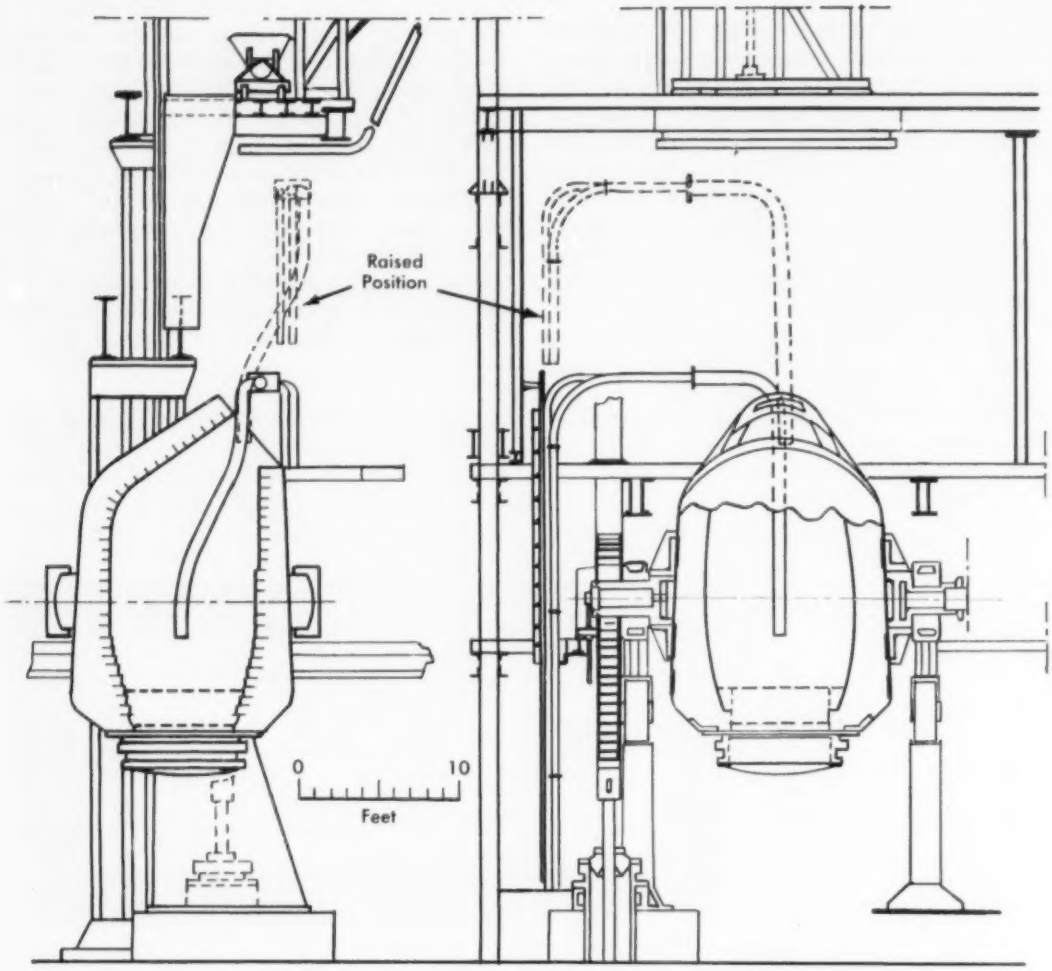


Fig. 2 – Drawing of the 30-Ton Converter and the Lance

iron) was cut in half. Blast pressure was 8.5 psi. (up from the normal 7 psi.). Coke consumption was reduced by about 60 lb. per ton of pig iron (about 3% below normal).

As predicted from the low-shaft experiments, carbon was higher and sulphur was lower than the standard production at all silicon levels in the pig iron (see Fig. 1).

New Steelmaking Process (OCP)

The oxygen-calcium steelmaking process (OCP) deserves very special attention, for it can be considered as a very important improvement not only in the refining of basic bessemer pig irons, but also for the others with less phosphorus. The process was invented by P. Metz, superintendent at the ARBED/Dudelange Steelworks in Luxemburg, and was described by him at the international meeting in June.

In this process, pig iron is ordinarily refined by oxygen and pulverized lime blown into the metallic bath through a lance and a tuyere, both water cooled. At the Dudelange works it has so far been used for basic pig. The average composition of pig iron is 3.7% C, 0.35% Si, 0.5% Mn, 1.85% P, 0.05% S.

The experiments are carried out in a conventional basic bessemer converter of 30-ton nominal capacity with the bottom tuyeres blocked.

Figure 2 is a drawing of the converter and of the lance. Oxygen pressure can be regulated between 0 and 240 psi., the oxygen flow between 0 and 5300 cu.ft. and the lime flow from zero to 880 lb. per min.

The lime has a size generally below 0.06 in. The oxygen has a purity ranging between 96 and 97%, but some heats were blown with 99.50%.

The actual technique may be described as follows: First, all the necessary pig iron is run into the converter with the main quantity of scrap, about one third of the total quantity of lime, possibly 450 lb. of bauxite and (since we aim at a high scrap rate) only a limited amount of ore (1000 lb.)*. If the pig iron is low in silicon, it is useful to add either sand or some siliceous product to facilitate foaming and to obtain a better slag for agricultural sale. The lance is then placed in high position and oxygen is blown in at a high rate.

foam so much that it might overflow. On the other hand, too sudden lowering of the lance would cool the slag unduly and increase ejections and brown fume. The flame radiation recorder enables the operator to adjust the height easily.

This second phase of the first period of the operation can be stopped at a carbon content above 1% if two intermediate deslaggings are desired. However, one usually chooses rather to prolong the blow until a carbon content of about 0.7% is reached, whereupon a single intermediate deslagging is carried out. The total time of blowing before tilting the furnace is about 14 min. The temperature reached is of the range 1570 to 1650° C. (2850 to 3000° F.),

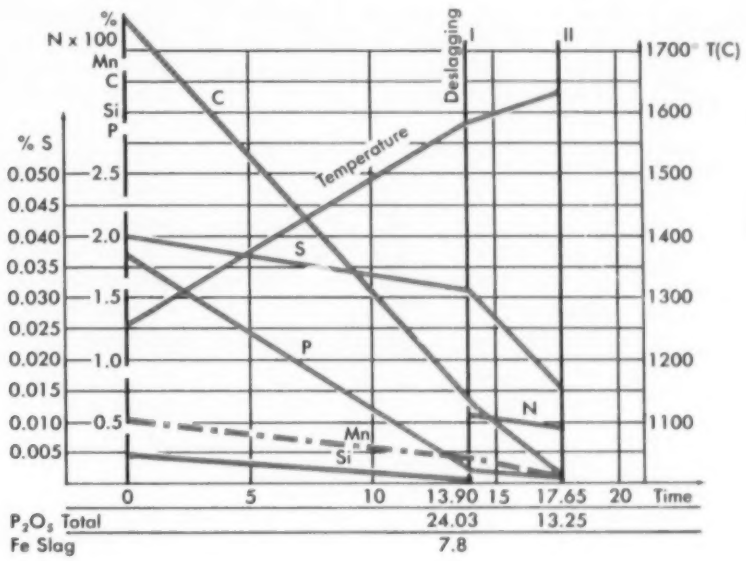


Fig. 3 — An OCP Heat With One Intermediate Deslagging

First Period

During this first period, which lasts for about 5 min., lime is not added since it causes excessive splashing. This procedure also facilitates the rapid foaming of the liquid slag within the first few minutes, thanks to the initial additions of ore, lime and bauxite. After the first 5 min. of pure oxygen blast, and without stopping the blowing, lime powder is added to the oxygen jet and the lance is gradually lowered at a rate depending on the radiation intensity of the flame. If the lance were kept too high, the bath might

and the foamy slag easily flows out without manual skimming. Lime consumption during the first phase varies depending on the silicon and phosphorus, and lies between 120 and 160 lb. per short ton of pig iron. The physical characteristics of the pig iron, so far as can be seen, do not affect in any way the course of the operation. It has been noted that relatively high-silicon iron (0.63%) connected with deep baths (48 in.) neither caused the foam to overflow nor decreased the yield.

The slag contained, on an average, 25% total P_2O_5 and 4 to 9% Fe. Citric acid solubility of the slag is excellent. The phosphorus content of the metal is, on an average, below 0.20% at time of deslagging.

*If an important proportion of scrap need not be handled, it is always possible to replace it by iron ore using the coefficients of thermal equivalence which are well known.

This rather late tilting of the converter when carbon is at 0.7% was chosen because the remaining blow and the thermal corrections necessary to obtain the desired final temperature could be determined with reasonable accuracy. With combined oxygen-lime blowing, this rather low carbon level is of no disadvantage as far as the eventual formation of a suitable liquid slag is concerned, because the slag is continually formed with the arrival of the lime at the point of impact of the oxygen jet. This is a unique feature when compared to the other top-blowing methods.

After slagging off and adding scrap (or iron ore) required for the temperature control, the second and last blowing period begins. According to the quality of pig iron and the degree of elimination of the first slag, it may be advantageous to add a small quantity of fluxing materials (bauxite or sand) after slagging off.

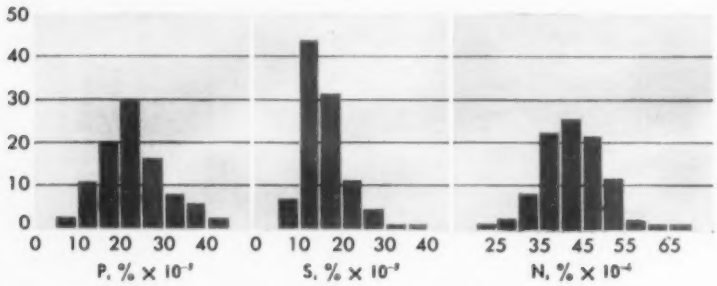


Fig. 4 – Frequency Chart for Phosphorus, Sulphur and Nitrogen in 150 Blows

Second Period

The technique utilized in the second period consists of simultaneous blowing of oxygen and lime powder until the end of conversion. The operation is timed with a stop watch; the time is a function of the carbon content determined at the first stop. Lime consumption during the second period is about 40 to 80 lb. per short ton of pig iron, giving a total of 160 to 240 lb. for the whole conversion. This second period lasts from 3 to 5 min. so the total blowing time varies between 16 and 20 min. for 28 to 31 short tons of steel. This corresponds to a total blowing time of 34 to 39 sec. per ton of steel. It is probable that, working steadily on an industrial scale, and with a well-equipped converter, it will be possible to arrive at a tap-to-tap time of 40 to 45 min.

When the last blowing period is completed, the slag is removed. After making a lime dam, the steel is poured into a ladle, with the required additions of solid or liquid ferromanganese.

Figure 3 shows the evolution of a typical heat with a simple intermediate slag removal, as described above.

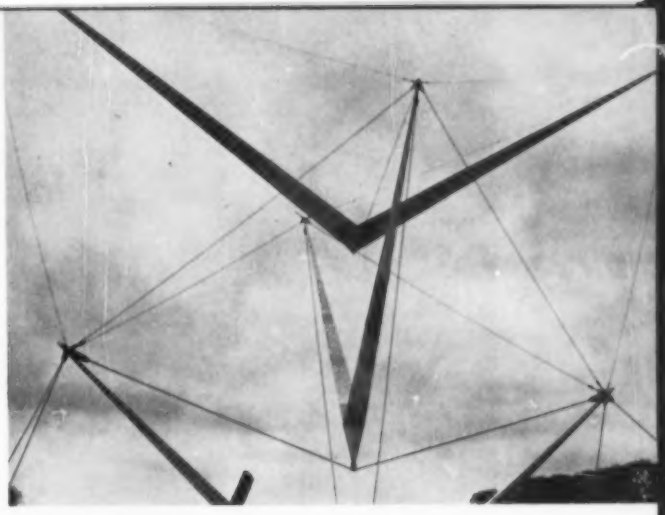
The main results already obtained in the industrial tests made with the OCP process can be summarized as follows: High metallic yield (about 90%); high consumption of scrap (430 lb. per short ton of steel); low consumption of oxygen (1700 to 1850 cu.ft. per ton) and lime (185 lb. per ton); great speed of refining (34 to 39 sec. per short ton of steel in a 30-ton converter); easy dephosphorization with high final carbon contents; high degree of desulphurization (60%); easy production of low-sulphur steels (less than 0.020%); nitrogen content in steel depending on the degree of purity of oxygen used in refining (with 98.5% oxygen, the average nitrogen level is 0.0044%, with 99.5% oxygen, the level drops below 0.003%); high citric acid solubility of the basic slag utilized as fertilizer; oxygen content of the steel at the end of blowing equivalent to those of openhearth steels. The frequency chart of Fig. 4 shows that statistically the process is under control.

In addition, it must be noted that the consumption of dolomite refractory is not higher, and perhaps even lower, than in the linings of the conventional basic bessemer process.

It follows that this process is a very economical one, which is perfectly suitable for the production of very high-quality steels.

Finally, it is interesting to note that for those steelmakers who wish to eliminate phosphorus during decarburization – that is, to finish the refining by driving the carbon down, as is done in openhearth steelmaking – the OCP process is one of the most attractive, since it can easily be fitted into the framework of a conventional basic bessemer steelworks.

Metals Defy Gravity



Steel cables were widely used as main tension members from which roofs are hung, clearing the exhibit space of all supporting columns. Light and strong supporting members enabled the architect to use colored plastics effectively. Brilliant metal more than held its own in the aesthetic balance. (T26n, 17-57)

Architectural Metal at the Brussels Fair

*By F. CHARLES THUM**

NOT LONG AGO a structural novelty appeared in architecture; it was to hang the walls from the roof. At the Brussels Exposition this was taken for granted. What everyone wanted to know there was, "What is the roof hung from?" The principal structural innovation and consequent new role of metal in architecture is the use of cables in solving the problem of covering large spaces. The architectural profession did not wait for the Brussels Exposition to tackle this problem, but the real flowering of an idea was here, and for the first time presented to an enormous public in striking form.

Architecturally speaking, the greatest benefit to be derived from large international exhibits is the opportunity to experiment with new ideas and present them to the view of millions of people. Two problems beset the architect in his effort to realize new ideas, namely, the conservatism of the public (all possible clients included) and the lack of familiarity of contractors and workmen with the required new techniques. Because of the temporary quality of an exposition, as well as the liberal budgets usually allocated for the constructions, architects find it much easier to overcome these two difficulties, and hence may risk the experiments which alone will prove the validity of the new ideas. The buildings once up, the very number of people who view them corrodes the resistance of conservatism; new ideas which stand the test of approval become a requirement in future buildings.

This does not mean that next year you will find cable-suspended vaults going up in great numbers. Labor must be trained and contractors convinced that it is worth their while to fool around with these new techniques, especially on the more modest jobs. Most difficult of all, a great many building codes will have to be adjusted. But the first big step has been taken.

Cables and wires were everywhere at Brussels. Cable cars carried passengers overhead on the main arteries, flags and pylons decorating the avenues were held in place with cables, ornamental contraptions marking entrance gates or visual focal points were composed of cables suspending massive elements in air in apparent contradiction to the laws of gravity. But these are mere variations on a single theme. The important idea is the integration of strong tension elements (cables) into the structural method of covering large spaces. Of the many solutions constructed at the Exposition, four will illustrate the variety of possibilities.

A Modernized "Big Top"

The Marie Thumas food products pavilion, designed by Baucher and Blondel, was directly inspired from Barnum and Bailey. In effect, a rectangular "big top" has been constructed, replacing tall wooden tent poles by trussed steel booms, tie ropes by cables, and canvas roof by plastic sheet. Even the principle of a continuous homogeneous surface to withstand wind pressure, anchored at the ground all around, has

*Architect, Vezelay, France.

Belgian Postal Pavilion (in Background)

been adopted. The booms, of riveted assemblages, thrust diagonally from interior floor points outwards to the corners. Their tips are connected in horizontal direction by cables curving down with the grace of a suspension bridge, and in the perpendicular direction by a triangle whose upper chord is a cable, visible only from outside, and whose lower two chords are steel beams. At the lower point of assemblage, steel cables run through pulleys and are anchored to the ground; they hold in tension a cable curving up, parallel to and between the other two cables already mentioned. On this "frame", cables are placed in tension, 2 ft. on centers, connecting the main cables to each other and to a continuous perimeter of reenforced concrete at ground level. Over this a plastic material has been stretched, sometimes opaque, sometimes transparent, the whole forming a continuous surface in tension from foundation to foundation. The main structural members having been painted black, the semirigid cable assemblages white, against a bright blue plastic, a very attractive decorative effect was obtained with the elements of structure alone.

A Bicycle Wheel

The American Pavilion has been covered with a bicycle wheel. Its rim is supported by a circular colonnade of two concentric rows of 36 slender, gilded steel columns stiffened with fins. The rim is actually a horizontal steel truss, hidden by a plaster soffit forming a deep cantilevered awning around the exterior of the building and an opaque cover over the outer ring of exhibits. Next come the spokes – wires in tension attached to this circular truss and radiating towards the center, where they are fixed to the hub – a cylindrical drum open to the sky. The spokes are placed 72 high and 36 low on the drum and support a plastic translucent roofing material above and a glorious gold fabric hung in festoons below. Thus a very large space indeed, a circle of about 300 ft. in diameter, has been cleared of the clutter of any vertical roof supports. It is worthy of note that the architect has been more interested in the color of gold as a decorative element than in the exploitation of metals in their natural shades. But the effects of light inherent in this structural system have been fully exploited – the opaque outer ring, the translucent light through the spokes, and the clear unobstructed sky in the central drum*.

Steel Trestles

The building of the European Coal and Steel Community, designed by Delatte and Maquestieau, hangs beneath six steel trestles. These trestles, similar to those supporting an architect's drawing table even including the slope of the top member, are of welded sheet steel, 90 ft. high, with a span of 180 ft. From the under side of each, three clusters of cables spray out, cone-shaped, serving as hangers for the flat deck roof. In turn, the curtain walls are hung from the perimeter of this deck, so this great rectangular building is literally hung beneath the six straddling trestles which form the principal decorative element of the exterior. In fact, these giant stirrups silhouette against the sky and are visible from a great distance, fittingly illustrating the fundamental interest of the organization which the structure houses.

A Merry-Go-Round

A final and dramatic example of the use of cables to support the cover of an enclosed space is the Belgium Postal and Telecommunications Pavilion designed by Architects Schmidt and Fourmanoit. A circular roof is suspended by cables from a central mast. This mast is a 180-ft. tube, 20 in. in diameter made of 0.70-in. steel plate, stiffened by four welded flanges 7×2.75 in. The bottom 25 ft. – that is, the part of the mast beneath the roof of the pavilion – is enclosed in a second tube, 32 in. in diameter. The mast is crowned by a 20-ft. plastic sphere, which houses antennas and electronic equipment ac-

*An international jury of architects has awarded first place to the Czechoslovakian Pavilion, second to the Belgian Engineering Pavilion, third to Great Britain, and fourth place was divided between West Germany and the United States.

cessory to exhibits in the Pavilion. Twelve cables attached to the top of the mast penetrate this sphere and go down at an angle to be fixed 20 ft. from the outer end of 12 metal roof trusses, 80 ft. long, composed of continuous bent tubes with welded joints. The inner ends of these trusses are attached to the mast. Concentric cables connect the top members of these trusses and, on the network thus formed, plastic elements are laid to form the roof deck. As is done in the Marie Thomas Pavilion, these trusses and cables, visible from beneath, are painted white to emphasize their decorative effect against dark blue or translucent plastic. To complete the stability of the structure, a pair of subsidiary cables are fixed to the under side of each truss and drawn in at an angle to be attached to a circular reinforced concrete beam in the floor, thus, by triangulation, stabilizing the roof deck against wind pressure and any tendency toward rotary movement. This beam is composed of prestressed reinforced concrete elements. The walls of this pavilion are entirely of plate glass set in metal frames. Since the roof is 25 ft. up, wind pressure requires these window frames to have considerable bulk, giving the unfortunate. impression that they support the roof.

Such use of cables for supporting roof structures illustrates the efforts of architects to use expositions to experiment in new fields. Another equally useful tendency is to push to the limits of refinement ideas which were equally novel in previous fairs. New ideas, by their very nature, are bound to entail a certain clumsiness, a robust ugliness, which time alone will eliminate. Thus, the architects of the Israeli, the Austrian, and the German Pavilions chose to refine rather than to innovate, but their contribution is no less useful; they are converting the public by charm rather than by shock. All three have used the post-and-lintel system with strong cantilevers, pushing the vertical supports back from the facade and emphasizing the exterior curtain wall. In the Israeli pavilion, Architects Hanani and Sharon have exploited no new structural principles; this pavilion is perhaps the best example of the proper use of architectural means, which have become a discrete and charming background, to develop the real purpose of the pavilion, namely to display exhibits.

Metal as Decoration

The Austrian and the German Pavilions have, on the contrary, used the architecture of the structures as part of the display, reflecting by the finesse and precision of the workmanship the same qualities which are apparent in their exhibits of precision tools, scientific instruments and other craftsmanship. Both have shut out the amusement-park confusion of the surrounding fair grounds, the Austrians by turning the view entirely towards the inner open patio of the building, the Germans by isolating the various pavilions in a wooded park. Both have chosen a few materials and emphasized them by repetition, quality and fine workmanship.

For the Austrian Pavilion, Karl Schwanger has raised a hollow square over a paved court, supported solely by columns at the four corners of the patio. The assemblage is of welded and bolted steel members, fully visible on the exterior. Flanges have sometimes been continued where not strictly necessary for structural design to emphasize the geometric decorativeness. Further emphasis has been obtained by fine execution of the welding and cutting, and by contrast of colors on different surfaces of the assemblage. The outer curtain wall is composed entirely of corrugated, translucent, ivory-colored plastic. The inner curtain wall, giving on the patio, is of plate glass and here the metal frames have been treated with the greatest care. The main members are of rectangular section, painted dark gray. The fillets required to hold the glass in place are also of rectangular section, of polished stainless steel, so designed that the two fillets, plus the thickness of the plate, equals the thickness of the painted frame. Thus, the complete assemblage makes a flush, rectangular section and the contrast of the two metals combined with the proportions of the openings produces a decorative effect of extreme refinement and beauty.

Ornamental Pile of Coins in Front of the Belgium Bank Pavilion

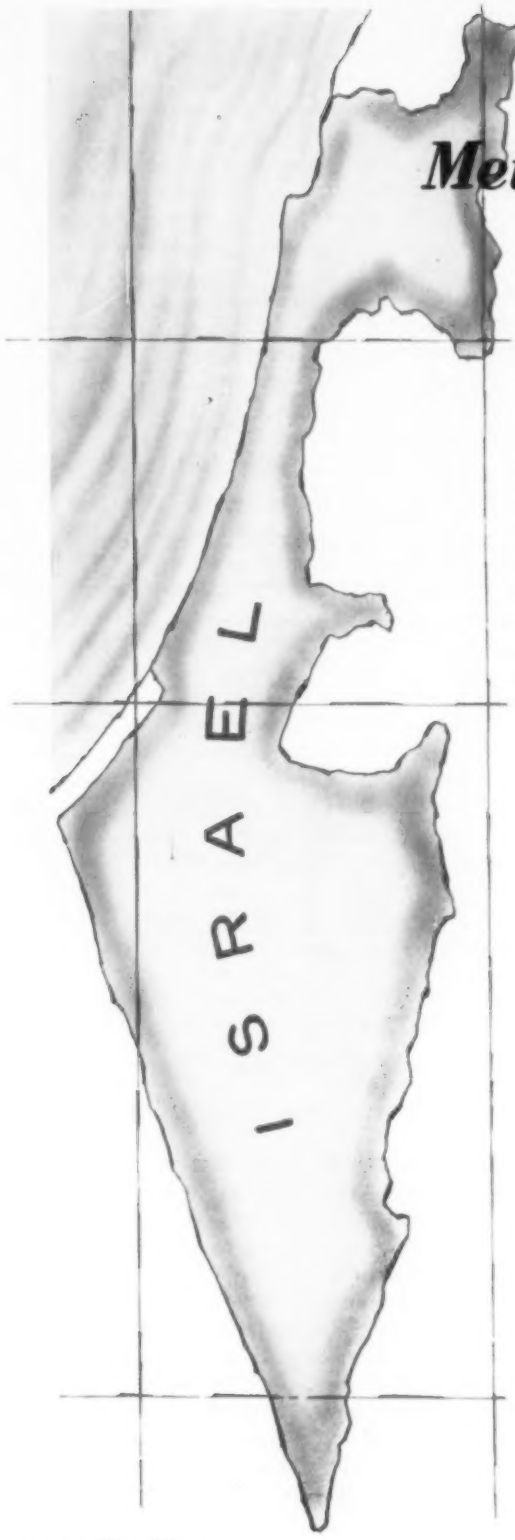
For the West German Pavilion, Architects Eierman, Ruf and Rossow have pushed the decorative qualities of the structural materials to the ultimate. Exterior walls are either non-existent (the air of the wooded garden entering freely to refresh the visitors) or of plate glass with the smallest possible metal frames. A hand rail is composed of a single pipe. The floor slabs of the square pavilions, supported by square steel columns set back from the facade, are strongly emphasized by the smooth white surface of the plaster soffits, the polished oak of the floors, and the black and white painted metal edge plates. All metal has been treated with judicious contrasts of black and white, chosen so as to emphasize different elements of the assemblage, and also to give a repetitive elegance to the architectural ensemble. Everywhere the theme of black and white metal, with a few discrete highlights of polished aluminum or stainless steel, gives unity to the group of buildings. Everywhere the attention to detail is apparent: Stairs, ramps, railings, cover joints, show cases, every problem has been met and solved, and the discrete emphasis of these solutions produces the decorative charm of the building. An unlimited variety of solutions have been found for show cases composed of metal frames and glass, but done so delicately, and with such discretion, that the result is the variety that eliminates monotony rather than that which creates confusion — a very notable achievement! Just to prove that the new fetish for using cables is quite within their grasp, the architects have hung a bridge and stairway entrance on cables from a mast set at the extreme end.

This West German pavilion fully illustrates the fact that the taste of the architect, combined with the science of the engineer, together with the ingenuity of both, can create the "stately pleasure dome" of Khubla Khan.

Metal as a strictly decorative element has also been extensively used. Gold is the very leitmotif of Edward Stone, the architect of the American Pavilion. He contrasts it to white, and makes fabrics, lattices, screens, a splendid cloth-of-gold stage curtain for his auditorium. In the Congo Pavilion were bas-reliefs for murals of bent sheet metal — aluminum for the white man and copper for the Negro — set off against a cocoa-colored background. Metal remains par excellance the material for sculpture, both of the traditional cast type and of the new forms of cut, bent, twisted sheet or wire. It is in great favor for mobiles, where its shiny luster catches light as breaths of air move it about. Many a baffle or curtain wall has been composed of pieces of sheet strung together on wires. The lobby of the Czechoslovakian Pavilion is furnished solely with the new style of metal sculpture, incorporating casting as well as wires in the compositions. The Austrian Pavilion undoubtedly put the greatest emphasis on metal as a purely decorative element, exhibiting the copper plates from which huge 18th Century engravings of architectural subjects had been printed on a number of sheets whose total assembly measures 6 or 8 ft. in each direction. A "strong room" display for medieval church treasures had been constructed of a forest of slender vertical iron posts from which jut, like leaves on a tree, iron platters about a foot square, rusted and stained with acids. Each object is enclosed in a deep metal case, exactly dimensioned to it, cast in iron with a drippy, heavy surface motif, faced with plate glass and brilliantly illuminated inside, these boxes being hung on the posts like the fruit of the tree. The glitter of the gold and jewel-encrusted objects against the background of iron and rust is a magnificent evocation of the crude contrasts of the epoch which produced them.

Of course metal abounded at the Brussels Exposition in all its traditional forms, being the material par excellance for rapid erection and easy demolition. For this reason it far outclasses reinforced concrete, while wood and masonry are fast disappearing from the architectural vocabulary. Pipe scaffolding used for structural supporting members is much in favor, and indeed it is a very logical choice for temporary structures, but it permits little refinement or innovation.

Much has been said about the Brussels Exposition being the apotheosis of plastic. But its use is logical only when it is combined with light supporting members; and steel supplies the proper partnership. Even independently of this, metal is the real star of the show, for it appears not only in many innovations, but also in all the traditional forms. The principal innovation (the use of cables) presents many problems for solution, problems of elegance, problems of watertight roof joints, problems of maintenance, problems of building codes. But these will be solved, just as those of refinement of the cantilevered post-and-lintel construction have been solved in the Austrian and German Pavilions. The way is already open for the organization of a future exposition.



Metallurgy in Israel

By ARIEL TAUB*

In the past decade, the number of metalworking establishments in Israel has more than tripled. Since they are nearly all quite small, they depend upon the Israeli Institute of Technology for engineering advice. About 400 undergraduate engineers are receiving instruction about metals. Furthermore, a department in metallurgy has been organized and already is offering graduate work and university extension courses. (A3, A4, A6)

A DECADE is a trifle in the life of an old nation and very rarely will any spectacular development occur in its tradition-bound industry. Not so in Israel, where the past decade was the first one in the life of the reborn state. It laid the foundations of future large undertakings, and also initiated many small factories and workshops, producing a large variety of metal goods.

To be able to comprehend and evaluate the difficulties and the achievements of this very young industry i. a very young nation, one has to get acquainted with its unique structure and with the fact that its development is achieved by decree rather than by evolution.

In 1948, when the State of Israel was declared, there existed in its borders altogether 335 metallurgical factories and workshops, employing 3464 people. In 1958, ten years later, the number of plants had increased 3.3 fold to 1158, with a labor force of 16,715. The summary is given in Table I.

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It is interesting to note that the number of workers per factory in 1948 was 10.3, and although this figure increased to 14 ten years later, the ratio remains in the same order of magnitude.

The metals industry in Israel is therefore an accumulation of small plants. Those which employ less than 20 workers number 63% of the total. In comparison, in the United States only 3% fall in this category.

Furthermore, our industry, though highly diversified, can claim only 2% of the country's total export. This means that its main contribution to the national economy at present is to save foreign currency rather than earning it.

In 1948 the metallurgists employed in the whole country could have been counted on the fingers. At present there is a growing demand for skilled engineers and more and more young graduates of the Technion take their Master's of Science and Doctor's degrees in metallurgy.

An analysis of the labor force gives a different picture altogether. The average unskilled laborer is recruited from the large number of immigrants flowing into the country. He may have been a butcher, a baker or a candlestick maker, but fortunately, as experience shows, people are very quick in adjusting themselves to new conditions. However, he lacks the tradition of his newly adopted trade; working a number of years in a small plant on some simple operation, he soon masters a "trade". Aided by evening courses, he may even advance to be a graded skilled laborer. Such a process, though vital for the ingathering of the exiles, considerably hampers the smooth operation and development of the industry, and is in no small measure responsible for the present situation wherein the industry is only able (for the most part) to execute simple operations. It can not now compete with the highly specialized modern industry abroad; before this can occur, the Israeli industry must acquire extensive basic theoretical knowledge by the engineers, well-grounded technical information by the foremen, and tradition-based skill by the workmen and artisans.

Table I – Development of the Israeli Metals Industry

Type of Industry	Number of Factories		Labor Force	
	1948	1958	1948	1958
Foundries and semifinished products	58	184 *(a)*	1410	2250
Finished products	67	213 *(b)*	487	3375
Fittings for gas installations	—	15	—	650
Tools, machine tools and industrial accessories	27	117 *(c)*	306	2205
Electrical equipment	31	75	391	2390
Agricultural machinery	3	25	70	500
Medical appliances	3	8	10	35
Fittings for the building industry	32	128	260	1390
Irrigation appliances	8	22	100	720
Metal finishing and heat treating	100	350	300	1200
Vehicles and spare parts	6	21	130	1460
Totals	335	1158	3464	16,175

(a) 116 of the new factories are nonferrous foundries employing on the average only six persons.

(b) With the exception of 56 plants with 16 workers each (on the average), the rest make consumer goods, such as 99 plants making kitchenware, 16 making washing machines and 11 making kitchen ranges.

(c) Manufacture of metalworking machinery (lathes, presses, welding machines) occupies 22 plants employing 570 persons, an average of 26 each.

The hardest hit are the small plants, whose labor force averages less than 20 workers. As a rule these plants are unable to employ any competent engineers and are therefore doomed to extremely slow development. Their managers recognize the disadvantages of being unable to advance beyond simple operations and are therefore hunting constantly for more advanced techniques. This is usually paid for very heavily; many a time – even if acquired – it will not be useful, because in the absence of qualified engineers it cannot be evaluated and therefore its success under modest production depends on

haphazard trial and error. Under these circumstances, it is natural that the shops keep all hard-gained knowledge a well-guarded secret, for two reasons:

1. The owners do not realize that the process probably has been well-known to specialists for a long time, and

2. The owners are afraid of immediate competition. The very fact that small-scale industry tends to shroud itself in secrecy means that it defeats itself by deliberate isolation. A most hopeful aspect, however, is that the urgent need for guidance from a centralized agency has been realized and is one of the reasons for establishing our Institute of Metals.

Problems of the Larger Plants

We find equally acute problems with the larger industrial groups which employ qualified engineers. The nature of their problems is somewhat different and on a higher scientific level.

While the small industry completely lacks laboratory facilities, some of the larger plants have installed well-organized and adequately staffed laboratories. Even the large Israeli factories would count as small plants in the United States and are obviously unable to embark upon long range research projects on their own. Their laboratories serve, as they properly should, for production control and occasional trouble-shooting. This industry (and more specifically the engineers) need to consult specialists well-versed in modern research techniques. Such men are usually found in universities and in our country are found on the staff of the Institute of Metals, which is in turn a branch of the "Technion", the Israeli Institute of Technology. Industry as a whole can thus benefit from the highly developed laboratories of the Institute, which are able to handle long range research projects as well.

The Institute of Metals

The President of the Technion, General Y. Dori, appreciating these problems of a traditionless metallurgical industry, secured the services of Prof. Daniel Rosenthal of the University of California, Los Angeles, through the good offices of the Technical Assistance Program of the United States. One of his earliest recommendations was to establish an Institute of Metals. This recommendation was taken up most enthusiastically and led to an agreement signed in 1957, whereby the Government of Israel provides the funds for the Institute's housing and operating budget, the American Technical Assistance Program provides the scientific instruments and other laboratory equipment, and the Technion provides the staff and administers the Institute.

Being a branch of the Technion, the objective was to train metallurgists at the same time it was solving technical problems. Undergraduate metallurgical training on a limited scale had already begun in 1953 at the Technion. Its scope had broadened in 1954 when a Division of Metallurgy was created within the chemical engineering faculty, and this Division was given autonomy in 1955 by transforming it into a Department of Metals.

In addition to the service courses given to various engineering departments, the Metals Department started refresher evening courses on various levels of general and special metallurgical topics. A limited amount of general consultation, process investigation and trouble-shooting was also offered to industry. The year 1956 saw the first enrollment of graduate students, and the Institute of Metals was inaugurated in 1957.

As practice cannot be devoid of theory, so industry cannot be divorced from science. This fundamental thesis, which underlies modern industry and husbands its development, is the major reason why the Institute of Metals, whose main function is to serve industry, is so closely connected with the Technion, the Israeli Institute of Technology.

Functioning of the Institute

Affairs are under the guidance of a Board of Governors which include representatives of the Government of Israel, the metallurgical industry, the Israeli Standards Institute, and the Technion. The director of the Institute of Metals reports to this Board, and under him is a series of laboratories, namely for casting, heat treatment, metal forming, machining, and metal finishing (including corrosion problems). While the two major activities of the Institute are educational and industrial, the two are very closely interwoven to form one organism.

The three national agencies – Government, industry and the Technion – charged the Institute with three different tasks.

The Government wants scientific aid in legislation and planning. For example, semifinished metallic products used as raw materials are now mainly imported by trade names rather than upon their required properties. Great amounts of foreign currency may be saved by a rational

reduction of the varieties of imported raw materials and a selection of the cheapest source.

Again, government bureaus are confronted daily with suggestions and applications for erecting or extending facilities for new developments as yet untried in this country. Evaluation of these plans is clearly a task for the Institute of Metals, which can use the problems in the training of future engineers. On the other hand, ideas for new developments require more extensive research, and these can be converted into research themes for students working for a Master's or a Doctor's degree. Last but not least is the task of raising the professional standard of practicing engineers, which is achieved through refresher evening courses, discussion groups, and symposiums on selected topics.

The industry – a group of small undertakings – looks to the Institute of Metals to serve as a large laboratory. The fees for an individual problem are low and the Institute works on a "pay-as-you-go" basis. At the beginning of activities, the problems presented were mostly of the curative type, meaning that the damage had already been done, mostly beyond repair, leaving open only the possibility of diagnosing the trouble and instructing the people on the job how to avoid recurrence. Lately the balance is even between curative and preventive inquiries, and this is to the credit of educational progress. It already shows a tendency to abandon trial-and-error methods in industry and to apply for guidance by the Institute. The curative type of problem offers excellent laboratory work for graduate students, enabling them to obtain first-rate clinical experience. The preventive type of problem, on the other hand, becomes part of the engineering curriculum. Diploma students do the investigations and prescribe the cure, and their reports serve as case histories which are studied in the elective courses in metallurgy by senior mechanical engineering students.

The Technion has the grave responsibility – being the only technological university in Israel – of producing competent engineers for Israeli industry. Specifically, for metallurgists, the Technion has charged the Institute of Metals with this task.

The curriculum is divided into three educational phases: In the lower undergraduate division two general courses are given to all engineering students, dealing only in a fundamental manner with the structure of materials, the general properties of matter, and conventional manufacturing processes.

In the higher undergraduate division there is a required course in physical metallurgy for third-year mechanical engineering students dealing with alloy theory, effects of alloying elements, heat treatment and general suitability of alloys for specific requirements. For senior mechanical engineering students, there are two advanced elective courses available dealing with industrial metallography. These courses are intended for students who plan postgraduate study for higher degrees in metallurgy. Graduate courses and laboratory training are devised to bring the student as close to industry as possible on as high a scientific level as can be achieved.

Society for Metals

The year 1958 saw the founding of the Israeli Society for Metals, which has set lofty aims for the future. It plans to be the instrument which will educate engineers in the art of cooperation, and through its monthly meetings compels industrial engineers to lecture to their colleagues, thereby arousing their interest in related fields.

The first issues of a quarterly bulletin called *Metal* appeared in August and have been distributed free of charge to some 700 interested persons throughout the country.

Conclusion

We feel that much has been achieved in this young country. Much more will follow. We would like our foreign friends to remember that the Israeli Institute of Metals is quite different in its origin than organizations of similar name in other countries. There, the societies have evolved from the industry. Here, the industry will evolve from the Institute – or, rather its product, namely, trained engineers. This may seem to be putting the cart before the horse, but in our case this is necessary, because it shows the horse what is in the cart!

The Israeli metals industry is very young and its Metals Institute has only functioned properly for the last year. Therefore, there is no past to look back to, and we cannot extrapolate into the future. Nevertheless the hope is justified that the Institute will be able to help the metal industry of Israel to reach the recognized modern standards.

Last but not least, the Israeli Institute of Metals will stand as a lasting tribute to the outstretched friendly helping hand of the government of the United States of America and its Operation Mission in Israel.

Welding and Metal Forming in Russia

*By ARTHUR B. TESMEN**

Electroslag welding is used to fabricate large parts from components while friction welding is claimed to be much more efficient than flash welding. The Soviets reportedly are constructing a 77,000-ton forging press and a 20,000-ton extrusion press which is considerably larger than similar equipment built for the U. S. heavy press program. (K6, F22, F24, W22p)

SINCE the first Sputnik was placed into orbit in October 1957, we have learned of the Soviet advances in rocketry, atomic energy, and basic science. What about progress in metalworking and fabrication technology – has it kept pace with advances in the more spectacular, attention-getting fields?

As a member of the United States group attending the conference on Vacuum Techniques in Steel at the Academy of Science's Institute of Metals in Moscow last summer, I had the opportunity to hear reports on current developments and to talk with a number of Soviet metallurgists and technologists in the metalworking field. This article will discuss Russian practices in welding, progress being made in forging and extrusion and the use of special metal forming techniques.

Welding by Friction

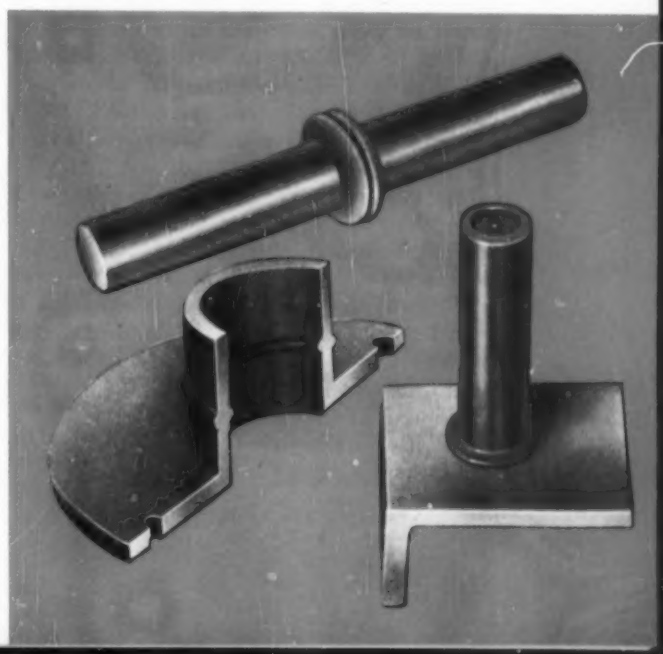
This method uses heat generated by friction of a part rotating at high speed, while in pressed contact with the piece to which it is to be welded. The principle is illustrated by an example: Two bars are butted along their axis with one fixed, and the other rotating at 3000 rpm. The bars are pressed together with pressure of 4600 psi. for mild steel, 9200 psi. for cast iron, and 1120 psi. for aluminum. Rotation develops friction followed by heat, which is localized. It takes several seconds to generate the heat needed. As soon as this temperature is reached, rotation is stopped. However, pressure is maintained (or sometimes increased) until completion of welding, after which the weld is cooled in air. Total welding time is 10 to 25 sec. and the energy consumption is only 10% that required for flash welding.

Foreign matter, such as absorbed and oxidized films, is removed due to friction and plastic deformation of the abutting pieces. Metal in the vicinity of the weld is actually upset, forming a collar or a bead, as illustrated in Fig. 1, which shows typical friction welded parts. Basic parameters of the welding process are: (*a*) speed of relative motion of the frictional surface, (*b*) abutting pressure, and (*c*) the amount of upsetting of the part. The first two can be varied within wide limits without significant effect on weld quality, but the third must be of optimum magnitude; otherwise there is danger of insufficient removal of oxides and grain growth.

Materials Joined – A variety of materials have been friction welded such as low-carbon, medium-carbon and free-machining steel, stainless steels, cast iron, brass, aluminum and titanium. The process also satisfactorily joins dissimilar metals,

*Metallurgical Engineer, Loewy-Hydropress Div., Baldwin-Lima-Hamilton Corp., New York.

Fig. 1 – Typical Parts Fabricated by Friction Welding



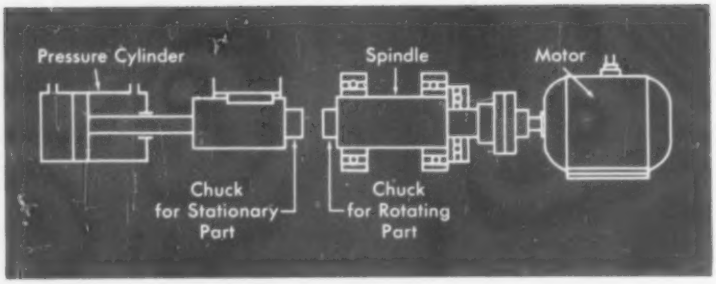


Fig. 2 – Machine Used for Friction Welding. One part rotates with the spindle. The other one is held stationary and pressure cylinder applies axial force

brass to steel, brass to cast iron, and cast iron to copper. Typical parts welded are round bars, flanges and pipe. A variant of the process joins two stationary parts, with a rotating part pressed between them, which becomes part of the joint. Welds have good tensile and bend properties.

Apparatus – Originally, the Soviets adapted machine lathes to this process. However, they wore out too quickly and had certain limitations with respect to dimensions of pieces and vibration. A new series of machines, shown schematically in Fig. 2, has been designed for the process. Chucks hold parts with their axis in line with the horizontal axis of the machine. One part rotates with the spindle by means of a motor. Pressure of a hydraulic or pneumatic cylinder moves the other part creating axial forces upon the friction surfaces. The latest Soviet machine has the following limits: maximum diameter joined, 2 in.; minimum diameter joined, 0.03 in.; maximum length, 16 in.; length upset, 0.10 to 0.25 in.

Electroslag Welding

Electroslag welding is an arc-less welding process for joining large parts. By this method, large forgings and castings which are difficult and expensive to manufacture have been replaced by weldments built up of smaller components. It is possible, under certain conditions, to join parts of unlimited thickness in one pass. Most important applications to date have been in pressure vessels, heavy machinery, and hydroelectric equipment.

How Process Works – Unlike arc welding with the open or submerged arc, heat in the electroslag process is derived from the electrical resistance of the slag. Welding is started by an arc which melts the flux. As soon as some flux is melted into a slag, the arc is extinguished and all the heat is derived from the current flowing though the slag.

A consumable metal electrode in form of a bar or plate is submerged into this pool. Electric current, passing between the electrode and the welded part through the molten slag, heats the slag bath and maintains its electrical conductivity. Temperature of the slag bath (up to 3200° F.) is much higher than the melting point of base metal and electrode. Thus, the slag melts the submerged electrode, and also melts the edges of the welded part. Molten electrode and base metals mix together forming the metallic bath (Fig. 3). As the continuously fed electrode is melted, the slag-metal bath rises, while the solidifying lower metal layers form a welded joint between the edges of the two joined parts.

Water cooled plates confine the molten metal and the slag. The amount of current flowing into the plate and the resultant penetration govern the depth of the slag pool, and are adjusted accordingly. The depth of the slag should be about 2½ in., and the depth of the slag plus the molten metal is about 3 in. Best conditions for obtaining a deep slag bath occur when vertical joints are made. Therefore, the process is used generally for vertical joints molded by means of water cooled copper assemblies. It can also be adapted to welding circumferential joints.

In electric slag welding, it is possible to join material up to 2⅜ in. thick using one stationary electrode; metal 6 to 8 in. thick is handled using three electrodes. With reciprocating motion of electrodes in the direction of plate thickness, it is possible to join thicknesses up to 16 in. using three oscillating electrodes. By increasing the number of electrodes or by using electrodes of larger round or rectangular cross section, it is possible to join metal of almost any thickness. Economic advantages of this method increase with greater thicknesses. Welding parts to about 2 in. thickness offers no economic advantages over multilayer welding; with parts over 4 in. thick electroslag is three to four times cheaper, and over 12 in. thick it is from 15 to 25 times cheaper.

Slag Welding Machine – A standard welder for thicknesses from 2 to 63 in. accommodates

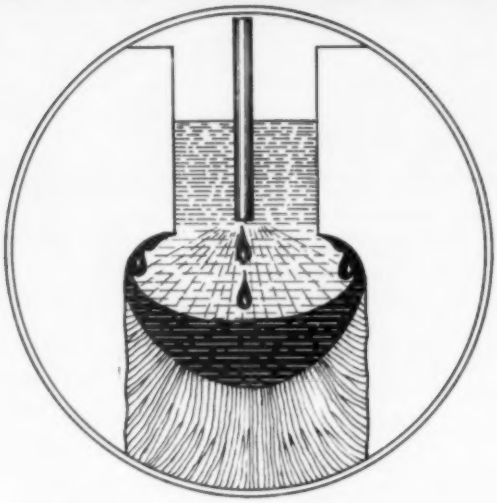


Fig. 3 – Electroslag Welding Process. Electric current passes between the electrode and welded part through molten slag

three coils of wire. It weighs 660 lb., is 5 ft. high and 46 in. wide, and is used for longitudinal and circumferential butt, fillet and T-joints. Both wire and plate electrodes up to 14 in. wide can be used. For welds up to 23 in. thick, wire electrodes are used. In its standard form, the welder is intended for straight welds, but by means of a series of relay terminals it can also be used for circumferential joints.

Other Machines – Besides this model there are several other types of machines using wire and plate filler-metal of varying diameters. Special equipment for the process includes an electromagnetic welder, which "walks" along a vertical seam during welding. Here the welder is held to the workpiece by means of a mechanism employing magnets. Two welders can be used simultaneously, on opposite sides of the seam. Another variant of the process uses a consumable-electrode guide tube, for welding of joints with curved cross section. Special positioning towers have been developed for electroslag welding of cylindrical vessels up to 26 ft. high, 13 ft. in diameter with wall thickness up to 23 in. Another installation is being developed for the circumferential welding of cylindrical vessels weighing up to 285 tons.

Electroslag Wire and Fluxes

Wire used is of various compositions determined by the base-material requirements. For example, wire for carbon steel welding contains 0.08 to 0.15 C, 0.35 to 1.10 Mn and 0.03 to 0.05 Si. Typical electrode is ⅛ in. in diameter. It is fed at 130 in. per min., using a current of 650 to 750 amp. at 42 to 46 v. Deposition rate averages 45 lb. per hr.

Table I – Composition of Electroslag Welding Fluxes

	AH 8	AH 22	F 27
SiO_2	33 to 36%	18 to 21%	46 to 48%
Al_2O_3	11 to 15	19 to 23	<3
MnO	21 to 26	7 to 9	24 to 26
CaO	4 to 7	12 to 15	<3
MgO	5 to 7	12 to 15	16 to 18
Na_2O+K_2O	—	1.3 to 1.7	0.6 to 0.8
FeO	1.5	1.0	1.5
CaF_2	13 to 19	20 to 24	5 to 6
S	<0.15	<0.15	<0.15
P	<0.15	<0.15	<0.15

Several types of fluxes are available; typical compositions for use with carbon steels are given in Table I. Welding time for various thicknesses is given below:

Plate Thickness	Number of Electrodes		Welding Time, Min.
	Stationary	Oscillating	per Ft.
2 in.	1	–	10
4	2	–	10
6	3	–	10
8	–	2	20
12	–	3	20
16	–	3	27

Thermal conditions for electroslag welding make preheating unnecessary; however, they also give a pronounced dendritic structure. When the weld puddle is too shallow, the dendrites are vertically oriented and hot cracking occurs. This is corrected by adjusting the depth of the slag bath; the dendritic structure is refined by normalizing at 1700° F. and tempering at 1200° F. Normalizing produces recrystallization and consequent grain refinement in the heat-affected zone. The mechanical properties of the heat-affected zone and the weld metal are improved and are equal to those of the weld metal. Postweld heat treatment is done in a furnace or by local induction heating for large pieces. Properties of electroslag welded joints are shown in Table II.

Electroslag Applications

Materials welded include low and medium-carbon steels (up to 0.40 to 0.45 C), austenitic stainless steels of the 18-8 type, and heat resistant steels. Titanium and some of its alloys have been welded by the electroslag method. Here oxygen-free flux with high melting point is used and welding is done in an argon atmosphere.

Hydroelectric Equipment – Turbine shafts are produced of steel forgings, and consist of a

Table II – Mechanical Properties of Electroslag Weld Joints

Location	Yield Strength	Ultimate Strength	Elongation	Reduction of Area	Notch Impact*
Base metal (0.25% C) (8 in. thick)	40,000 psi.	71,000 psi.	31.5%	59%	12.3
Weld metal, as welded	43,000	72,000	19	31	10
Tempered at 1200° F.	44,000	76,000	20	33	11.7
Normalized at 1700° F. and tempered at 1200° F. in furnace	37,000	68,000	33	65	14.5
Normalized by local induction heating	41,000	72,000	30	61	13
Heat-affected zone (induction heated to 1400° F.)	39,000	71,000	26	55	17
Base metal (0.19% C)	34,000	64,000	34	63	14.8
Weld metal normalized and tempered across the weld by induction (transverse)	35,000	63,000	32	64	11
Same, longitudinal	31,000	61,000	35	65	12.5
Heat-affected zone	29,000	62,000	30	70	18

*In m-kg. per sq.cm.

large cylinder with one or two flanges. This large shape is difficult and expensive to forge because of difficulties in the cylinder-to-flange transition. By forging the cylinder and the flange separately and joining them by welding, costs are lowered, metal is saved and the production cycle is shortened. Welded construction permits hollow forging of the cylinder and reduces machining allowances for the flange. Further savings are being made by making the flange as a casting, produced closer to final dimensions, thereby reducing machining.

Similar methods are being applied in fabrication of strutting mechanisms for large excavators, piercing cylinders for extrusion presses and frames for forging presses.

Other Soviet Developments – Some idea of the scope of other Soviet activities in welding is given by this list of some of the processes currently under development: vertical submerged welding; powder flame cutting; automatic inert-gas-shielded welding; CO_2 shielded welding (up to 15 lb. per hr.); resistance welding without prior cleaning; manual and automatic cold pressure welding of aluminum and copper; ultrasonic soldering; welding without preheat; mechanization of welding for heavy machinery, pressure vessels, shipbuilding and piping; joining pipe by flash welding; submerged-arc welding of pipe in the overhead position; circumferential welding of pipe using CO_2; ultrasonic testing of weldments; studies on heat flow in welding.

Forging Practices

The Soviets have been producing heavy presses during the postwar years which have been designed along conventional lines. Their latest developments, however, are of great interest. I was shown a schematic drawing and given data on a 30,000-metric ton vertical forging press of tubular design. By utilizing tubes instead of columns for guiding and taking up the loads, they claim to be producing a press weighing 10% of that of a conventional press capable of exerting the same effort.

Another development of great importance is a 77,000-ton forging press for light alloys which I was told is currently being constructed. This giant, when completed, will be the largest forging press in the world, dwarfing the 50,000-ton presses in this country.

Sectional Forging – This technique is widely used by Soviet engineers to forge large crankshafts and turbine disks. It consists of forging separate sections of a shape, one at a time, rather than the entire section. This way presses of lower capacity can be used than would be required by conventional forging.

Extrusion

Their position in extrusion appears to be similar to that of forging. A number of extrusion presses, designed along conventional lines, are in operation with capacities up to 12,000 tons. However, a 20,000-ton press is under construction, which will exceed the capacity of our similar largest piece of equipment by 6000 tons.

Thin-Walled Aluminum Tubing – Bridge die extrusion is used for making high-strength thin-walled aluminum tubing. The process involves three consecutive metal forming operations:

1. Tube blooms are extruded with so-called bridge dies.
2. Extruded blooms are rolled by the Mannesmann process.
3. Rolled tubes are cold drawn to finish size.

Combination of these three operations gives a wall thickness down to 5/64 in., both in hard and soft alloys with good surface quality.

Continuously cast ingots, 8.8 in. in diameter, of aluminum-magnesium alloy (our 5052), aluminum-magnesium silicide (our 6061) and aluminum-copper-manganese-magnesium (our 2014 and 2024 alloys) are cut to 18-in. lengths and machined to 7.5 in. O.D. These billets are extruded in a 3500-ton press using a 8.1-in. container.

Rolling Round Periodic Shapes

The method illustrated in Fig. 4 produces long shafts of rounds of variable periodic cross section. Its advantages, as claimed by the Soviets, are high production rate and saving in machining resulting from close tolerances.

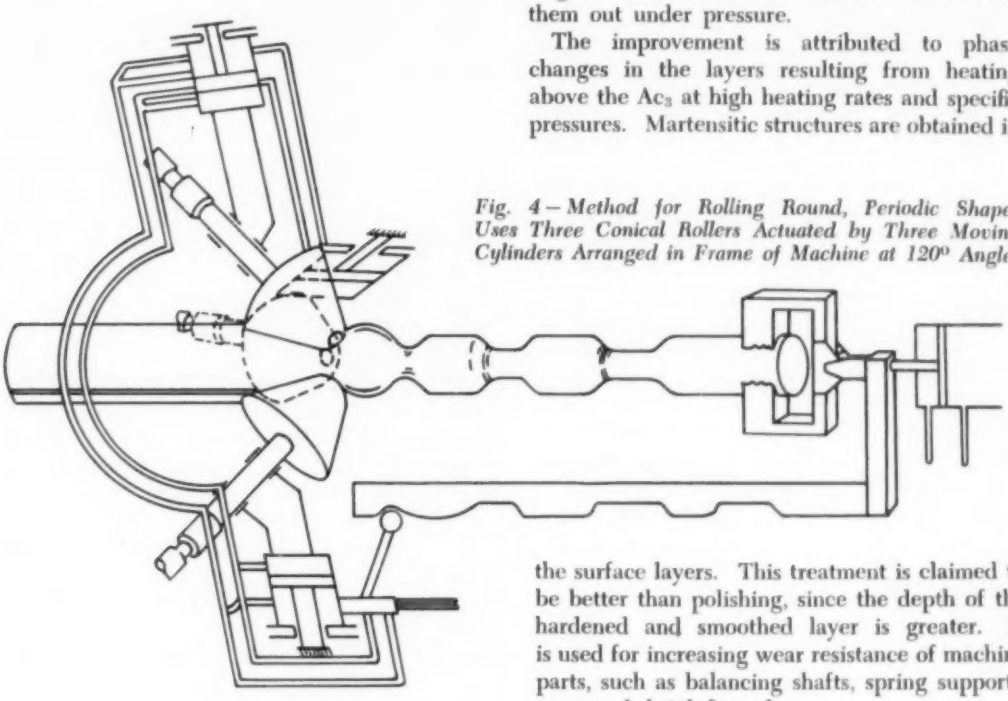


Fig. 4 – Method for Rolling Round, Periodic Shapes Uses Three Conical Rollers Actuated by Three Moving Cylinders Arranged in Frame of Machine at 120° Angles

The technique utilizes three conical rollers actuated by three moving cylinders arranged in the frame of the machine at 120° angles. The billet or bar is heated by induction to 1550° F. and placed between the spread rollers until it rests in the chuck. The chuck automatically grips one end of the bar. Then the rollers are brought into the starting position. They contact the bar and rotate it. At the same time the hydraulic tension arrangement moves the chuck away from the rolls, thus moving the bar so successive sections can be rolled. The rollers are brought together or spread apart by means of a tracing device. The combination of these actions produces cross-spiral rolling of the cross section.

Tube Rolling – Very thin-walled tubing of carbon and alloy steel and nonferrous metals is produced by cold rolling. Tubing 8 to 15 mm. (about 5/16 to ⅝ in.) in diameter with wall thickness of 0.25 mm. (0.01 in.) has been cold rolled with satisfactory surface quality and tolerances.

Leveling Metal Surfaces

An electromechanical method is used which consists of applying simultaneous high-magnitude low-voltage currents and pressure to a metal surface. The current heats the microscopic ridges in the surface to deform and smooth them out under pressure.

The improvement is attributed to phase changes in the layers resulting from heating above the Ac_3 at high heating rates and specific pressures. Martensitic structures are obtained in the surface layers. This treatment is claimed to be better than polishing, since the depth of the hardened and smoothed layer is greater. It is used for increasing wear resistance of machine parts, such as balancing shafts, spring supports, press and shrink fit surfaces.

Cold Working – Soviet machine builders are devoting considerable attention to the use of cold work to improve fatigue strength. They stated that the principal tool which is enabling them to manufacture the 77,000-ton press is electroslag welding combined with cold work. They cold work by hammering, shot-peening and by use of rollers. Blooming mill rolls are cold worked which is claimed to give a 50% increase in their life.

Metal Parts for Operating At Higher and Higher Temperatures

*By D. A. ROBINS**

Several hundred experts in the field of powder metallurgy gathered at Reutte, Austria, in June to discuss "High-Melting Metals, Their Manufacture, Properties and Applications". Columbium, molybdenum, tungsten, tantalum appear to hold most promise for the future. (H-general; EG-d37, Cb, Mo, W, Ta)

AN IMPORTANT PROBLEM facing metallurgists today is that of producing parts capable of operating at temperatures higher than those attainable with the conventional cobalt-base or nickel-base alloys. It seems unlikely that the operating temperature of the last mentioned can be increased very far beyond present practice owing to the relatively low melting points of the basic constituents cobalt and nickel. Here, at least, is one good reason for looking again at the properties and potentialities of the elements possessing very high melting points. The international conference held in Reutte, Austria, in June was therefore of importance, since more than 30 papers were presented for discussion around the theme: "High-Melting Metals, Their Manufacture, Properties and Applications."

Six years ago the Metallwerk Plansee, Austria, organized its first seminar to bring together powder metallurgists and others working in related fields. That first meeting has been followed triennially. From the quality of the papers and the large number of eminent men present at the third seminar in 1958, it is apparent that these meetings have become established as important international gatherings.

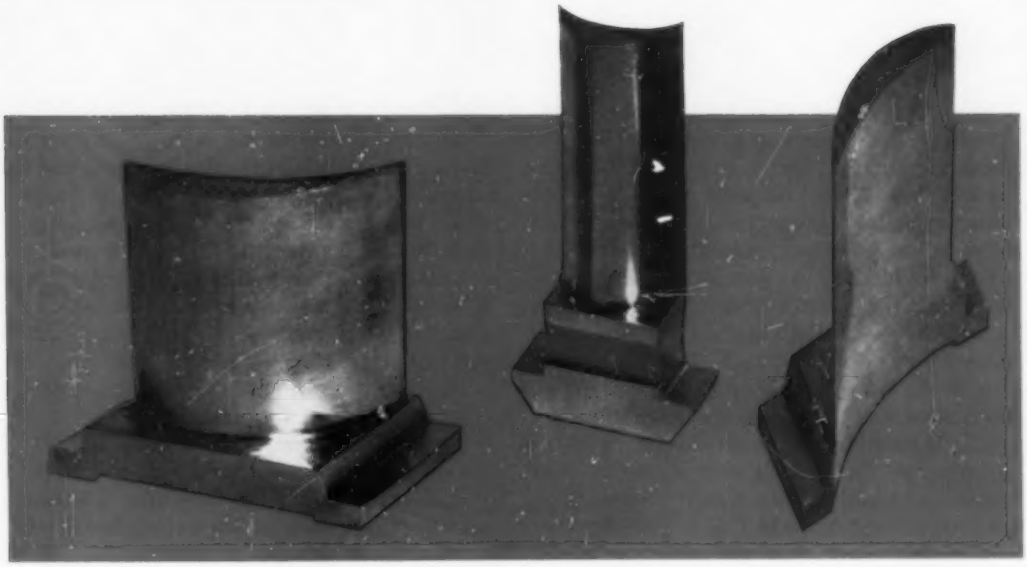
Molybdenum and Its Alloys

From a comparison of the properties of structural materials available for service under various conditions of temperature and stress, J. J. Harwood and N. E. Promisel of the Office of Naval Research, Washington, D.C., concluded that, for temperatures above about 1800° F., molybdenum-base alloys have superior mechanical properties over known alternative materials – such as, for example, bonded titanium carbide cermets which exhibit good high-temperature strength but poor ductility and thermal shock resistance. For use in a hot oxidizing atmosphere, however, molybdenum-rich alloys must be protected to prevent catastrophic oxidation. Although considerable effort has been directed towards the discovery of an all-purpose protective coating, it has not yet been obtained.

The wide range of special coatings now available permits the use of molybdenum alloys under oxidizing conditions at high temperatures, although the particular coating selected must be related to the specific operating conditions. Helmut Bückle, Organization National de Recherches Aérodynamiques, Paris, considered specifically the oxidation of engine parts, and it is apparent that coatings so far developed are not suitable for airplane engines.

The melting of molybdenum and its alloys using a consumable electrode in a vacuum arc furnace, described by Robert R. Freeman of the Climax Molybdenum Co., New York, has produced 12-in. round ingots weighing up to 2000 lb. In this practice, molybdenum powder is compacted semicontinuously into a rod, and before arc melting, the rod is sintered by resistance heating. (Carbon is added to the powder to facilitate deoxidation during melting.) Such ingots can be extruded into tubing and sections, and components of complex shape can be prepared by hot forging. In the discussion of his paper, Freeman agreed that the production of satisfactory welds in molybdenum is still a problem, although arc-cast molybdenum is preferable to powder metallurgy material in this respect.

*Research Laboratories, General Electric Co., Ltd., Wembley, Middlesex, England.



Turbine Components Made of an Alloy of 64% Cobalt, 30% Chromium and 6% Tungsten. Sintering method to obtain tiny cooling passages was described in Metal Progress, *March 1956, p. 52.*

At the second Plansee Seminar in 1955 the remarkable workability of a molybdenum alloy containing 35 at.% of rhenium was commented upon, and at the 1958 meeting J. D. Baird, G. A. Geach and A. G. Knapton, of the Associated Electrical Industries Laboratories, Aldermaston, England, reported enhanced ductility for a molybdenum alloy containing 14 at.% of osmium, but the effect was not as marked as that found for the earlier molybdenum-rhenium alloy. From the examination of molybdenum-rhenium and tungsten-rhenium alloys, R. I. Jaffee and C. T. Sims of Battelle Memorial Institute, Columbus, Ohio, concluded that the ductility of the molybdenum alloy containing 35 at.% rhenium is associated with a change in the nature of the grain-boundary oxide. Whereas in unalloyed molybdenum the oxide is apparently wetting the grain boundary, in the alloy the oxide particles are apparently not wetted. The nature of the oxide phase is unknown.

Tungsten and Its Alloys

If the progress of the metallurgy of tungsten can be judged from the proceedings of the Reutte meeting, little advance has been made in the last few years in comparison with molybdenum. Three papers concerned with the recovery and recrystallization of tungsten under various conditions were presented. A convincing explanation was put forward by G. D. Rieck of Philips' Lamp Works, Eindhoven, Holland, for the well-known dependence of the recrystaliization texture of tungsten wire on the presence or absence of grain-growth inhibitors. (In passing it may be noted that accurately defined scientific terms are sometimes lacking. In discussions on recovery in worked tungsten, the terms "recrystallization in situ" and "polygonization" both apparently described the same thing!)

Tungsten-tantalum alloys prepared by arc melting or by powder metallurgy were appraised by Horst Braun, Richard Kieffer and Karl Sedlatschek, Metallwerk Plansee. A continuous series of solid solutions is formed across the whole diagram. The low ductility of alloys with more than 10 to 15% W makes it difficult to predict any serviceable applications.

Columbium

After reviewing the available methods for the preparation of ductile tantalum, G. L. Miller of Murex Ltd., England, concluded that, due to the difficulties encountered in removing impurities, preparation by arc melting had no advantages over the powder metallurgy method. It was forecast that electron-bombardment melting may become of importance in the future.

This forecast was underlined by the success which has been achieved in the large-scale melting of columbium by electron-bombardment, as reported by C. A. Hunt of Temescal Metallurgical Corp., Richmond, Calif., and F. Krall of Degussa, Hanau, Germany. In equipment such as described in *Metal Progress* in December, 1958, an annular tungsten wire surrounds the melting zone; the electrodes are formed and directed so that, in addition to continuous melting of the material above the furnace hearth, a molten pool of metal is also maintained on the

hearth. To prevent glow discharge, very high pumping rates maintain a sufficient vacuum within the furnace. The usefulness of the technique is not limited to columbium, as other refractory metals such as tantalum, tungsten and molybdenum have been melted successfully.

The production by powder metallurgy of columbium (or "niobium", as it is now called in Europe) by the United Kingdom Atomic Energy Authority was described by L. R. Williams and T. J. Heal. Sintered bars up to 7 sq.in. in cross section and weighing 35 lb. are being manufactured. If round bars of these dimensions are to be prepared, the particle size of the original powder is important. With fine powder, rapid sintering entraps impurities and gross internal cavities are formed. This difficulty is overcome by the use of relatively coarse powder, but the coarse powder results in a low sintered density. Residual porosity may be removed by cold working. Scrap metal is reclaimed by embrittling it with hydrogen, crushing to powder and then degassing the powder.

Considerable attention has been given to the corrosion of columbium by liquid sodium, to assess this combination of "can" and coolant in an atomic reactor. From compatibility studies, it had been found that the corrosion rate of the columbium is insensitive to the initial surface finish, but is markedly dependent on oxygen level, temperature and velocity of the sodium.

Like other refractory metals, columbium cannot be heated in an oxidizing atmosphere without excessive oxidation. R. I. Jaffee of Battelle Memorial Institute, Columbus, Ohio, reported an investigation into the rate of oxidation of binary alloys. Titanium additions were most effective as oxidation dampeners. In the temperature range 1100 to 1800° F., the rate of oxidation of columbium is reduced by at least one order of magnitude by the addition of 25 at.% Ti. Additions of vanadium, molybdenum and chromium were good, but less beneficial.

Developments of Powder Metallurgy

Some of the most interesting papers presented at the Reutte Conference were related specifically to developments in the theory and practice of powder metallurgy. (The comparatively large-scale production of columbium by powder metallurgy has already been mentioned.)

A new approach to a subject is always refreshing, and this was true of a new viewpoint on sintering presented by F. N. Rhines of the Carnegie Institute of Technology, Pittsburgh. He considered the sintering process in terms of the topological genus* of the surfaces of the body being sintered. One objection to this is that the effects of such important variables as particle shape and size are excluded. The usefulness of Prof. Rhines' approach is therefore limited.

Experiments on the sintering of single-crystal spheres of alumina were described by G. C. Kuczynski, University of Notre Dame, L. Abernethy and J. Allan, who concluded that the predominant mechanism of material transfer in this process is volume diffusion.

The results reported by H. H. Hausner of Penn-Texas Corp., New York, on the slip casting of stainless steel powders indicated a valuable method of preparing sintered components without first making expensive metal dies in which to compact the powder. The "slip" is a dispersion of metal powder particles in a liquid (with chemicals added to prevent nonuniform settling). Such a dispersion is poured into a plaster of paris mold which absorbs most of the liquid. Hausner was able to obtain densities of slip-cast stainless steel, after sintering, comparable with those from conventional procedures.

Another potentially important development in powder metallurgy is the hardening of metals and alloys by a finely dispersed refractory phase. Supplementing a paper presented before the summer meeting of the American Society for Testing Materials (see *Metal Progress*, p. 119, August 1958), W. M. Schwarzkopf and N. J. Grant of Massachusetts Institute of Technology, Cambridge, Mass., described the preparation and properties of pure metals – especially nickel – containing a fine dispersion of alumina produced either by mixing the metallic powder with very fine alumina or by internal oxidation of an appropriate alloy. The strength of the dispersion-hardened materials increased with increasing alumina content and for a given alumina content internal oxidation gave better properties than mechanical mixtures.

*"Topological genus" is a mathematical term related to the shape of a body. Any *solid* – no holes – may be manipulated into a sphere. It is said to have a surface of "genus zero". If it has one hole in it – say a doughnut – it has to be cut once to make a body which can be manipulated into a sphere. It has a surface of "genus one". Consider a sieve: If it has 36 holes in it, it will require 36 cuts (the holes do not connect, one to another) and it has a surface of "genus 36". In a porous body like a powder metal compact, genus cannot be evaluated by counting the holes because the holes interconnect. Thus a sponge made of crumpled wire would be full of holes yet have genus zero.

Anodizing and Coloring Aluminum in Britain

*By TOM BISHOP**

Preferred anodic coating for architectural applications is 0.001 in. thick, but for some uses thickness of 0.0006 in. is satisfactory. Procedures are given for pretreatment, anodizing and coloring to produce a light-fast finish. (L19, T26n, 17-57; Al)

ALUMINUM is being used at an increasing rate in natural and colored finishes in curtain wall construction for exterior of buildings. Field tests on anodized panels in a wide variety of colors, exposed for periods of up to ten years, have given useful data on the relative "light-fastness" of colored finishes. The gray color produced by natural anodizing of the aluminum-silicon alloys is permanent. Colors produced by inorganic pigments (available in light gold to brown shades) have lasted with complete satisfaction on panels exposed up to ten years. Only the better "light-fast" organic dyes can be recommended, and these show no significant color change until after five years or more.

To demonstrate possibilities available by the use of color-anodized aluminum for building exteriors, the Aluminium Development Assoc.

*Metallurgical Consultant, John Miles & Partners (London) Ltd.; Consulting Editor, *Metal Progress*.

staged an exhibition in London, England, in October 1958, which was well patronized by European architects, fabricators and anodizers. As a result of continued industrial research, the A.D.A. has been able to draw up recommendations on processing requirements for light-fast weather resistant coatings, and has supplied information to enable at least two useful publications* on recommended processes to be made available.

An anodic coating thickness of 0.0010 in. minimum is preferred but for certain applications, such as shop fronts, 0.0006 in. minimum is satisfactory. The film thickness may be measured nondestructively by instruments using eddy current principles (see p. 101). Two such instruments are the Solus-Schall Isometer (Solus-Schall Ltd., 15-18 Clipstone Street, London, W.1, England) and the American Filmeter (American Instrument Co., Inc., Silver Spring, Md.). The latter is a portable instrument running from batteries.

Texture Improves Finish

As required by the application, the surface may be textured by mechanical or chemical means. Mechanical finishes may be achieved by polishing, blasting with abrasives or scratch brushing. Several points of caution should be kept in mind: Steel abrasives should not be used for grit blasting. Suitable methods are those using alumina, aluminum alloy shot or vapor blasting. Carbon steel or brass wires should not be used for wire brushing; stainless steel brushes are suitable. Sometimes chemical treatments follow mechanical finishing. These include matt etching and chemical or electrochemical brightening. Hydrochloric acid and chloride-containing solutions should not be used. If smudge is produced by etching attack in the chemical treatments, it should be removed by subsequent acid dip.

Anodizing Procedures

It is important that a clean surface be obtained prior to anodizing by a suitable combination of processes, as shown in the flow sheet in Fig. 1.

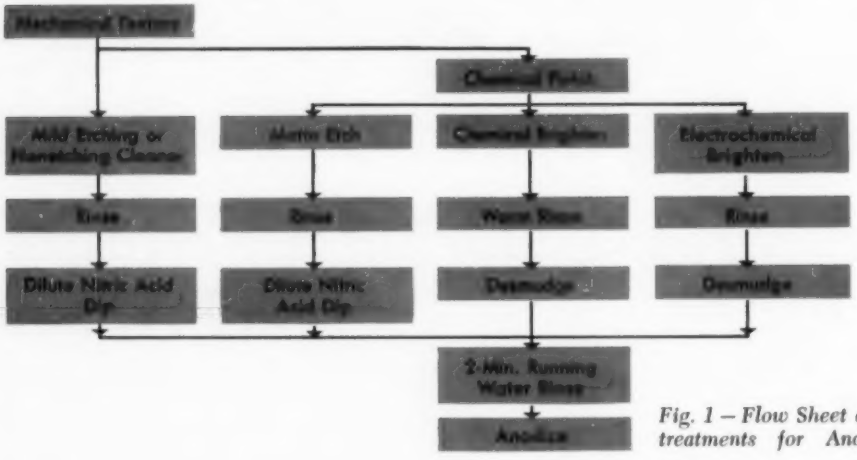


Fig. 1 – Flow Sheet of Pretreatments for Anodizing

A 2-min. running water rinse is required immediately prior to anodizing. The composition of the anodizing bath should lie between 6.5 and 9.5% by voume (2.4 *N* to 3.6 *N*) of sulphuric acid (concentrated – sp. gr. 1.84), controlled to within ± 0.2 *N* of the nominal value. The bath should be made up with deionized water. The concentration of dissolved aluminum in the solution should not exceed 20 g. per l. and dissolved chloride should never exceed 0.2 g. per l. (as sodium chloride).

Temperature of the anodizing bath should be fixed between 65 and 71° F., never exceeding the latter figure, and should be controlled within ± 2° F. of the nominal temperature in this range. Refrigeration equipment may be advisable; its use makes it unnecessary to limit the maximum total current used.

*"Color-Anodizing of Aluminium for Exterior Work", *Architects' Journal* (London), Information Sheet 41 B 2.

"Architectural Anodized Aluminium", *Metal Industry*, Sept. 5, 1958; Aluminium Development Assoc. Reprint R. P. /74. The latter may be obtained from A.D.A., 33 Grosvenor Street, London, W.1, England.

Table I – Color-Fast Dyes for Use in Exterior Applications

Color		Pigment (Inorganic)
On Silver-Anodized Surface*	On Gray-Anodized Surface†	
Silver	Gray	None
Gold	Brown	Ferric ammonium oxalate
Bronze	Dark brown	Successive dips in cobalt acetate and potassium permanganate
		Dye (Organic)
Yellow		
Green	Green	Kiton yellow 7 GF; Quinoline yellow A 200‡
Blue	Dark green	Aluminum green GLW
	Dark blue	Sandoz light blue; Oxanal blue CB‡
Black	Black	Aluminum black MLW

*Silvery appearance results from anodizing pure aluminum and most alloys.
†Aluminum alloy with 5% silicon.
‡These two dye-stuffs are essentially identical.

For anodic films 0.0010 in. (25 microns) thick, the work should be anodized under conditions which provide not less than 900 amp-min. per sq.ft. of surface, in a time not exceeding 75 min. (12 amp. per sq.ft. minimum). Recommended conditions are 60 min. at 15 amp. per sq.ft. For anodic films 0.0006 in. thick (15 microns), 540 amp-min. per sq.ft. in a time not exceeding 45 min. is required. Recommended conditions are 36 min. at 15 amp. per sq.ft. The voltage should be adjusted to provide a constant current density during the anodizing period, particularly for the alloy containing 5% Si. This particular alloy requires equipment capable of producing up to 24 v. After anodizing, work should receive two cold water rinses in clean flowing water; these rinses should be for periods of not less than 2 min.

Coloring the Anodic Film

Dyes recommended for color-fastness in exterior applications are given in Table I, which lists dyes and pigments which have been found to have sufficient color-fastness for exterior applications when tested both by external exposure (for at least five years) and by accelerated tests. Only a few dyes, out of several hundred tested, are recommended at the present time.

When aluminum-silicon alloys are used, the gray coating produced on anodizing will modify the color given by the dye. (The 0.0010-in. anodic film is darker than the 0.0006-in. one.) With the green and blue dyes, the color becomes darker; yellow dye gives a shade of green, gold pigment results in a brown finish and the bronze pigment gives dark brown. Pastel tints produced by low dye concentration and short dyeing times are not light-fast. No red color can be fully recommended at this time.

Sealing Process

Colored work should be immersed in a clear running water rinse for at least 2 min. and then sealed, using one of the following procedures:

1. **Nickel Acetate Fixing and Water Sealing**– This method is used following the blue, black and green coloring treatments. It must not be used with the Kiton yellow 7 GF or Quinoline yellow A 200 dyes. The work should be immersed in a solution containing 5 g. per l. of nickel acetate and 5 g. per l. of boric acid at a pH of 5.5 to 5.8 and a temperature of 167 to 176° F. Time of treatment is 5 min. This is followed by water rinsing and then by water sealing in de-ionized or distilled water, at not less than 208° F., and a pH of 5.5 to 6.5 for 30 min. Alternatively, sealing in dry steam at 212 to 240° F. for 30 min. may be used.

It is important that the temperature of the water sealing bath shall not fall below that specified. The pH value should be maintained in the range required and not allowed to fall because of carry over of acid from the processing baths.

2. **Water Sealing** – This treatment should be employed for gold, bronze and yellow coloring treatments, and for clear anodic finishes. The work should be immersed in de-ionized or distilled water at not less than 208° F., having a pH of 5.5 to 6.5, for a period of 30 min. Alternatively, sealing in dry steam at 212 to 240° F. for 30 min. may be used.

Atomic Energy in Canada

*By DAVID A. KEYS**

Canadian activities are restricted to peacetime uses of atomic energy. Over 100 "Cobalt-60 Theratrons" have been sold to 20 countries for treatment of malignant diseases. Long and successful experience with heavy water as a moderator for chain reaction in natural uranium enables them to use this principle in the design of their first power plants. (W11p, 1-52, 16-62)

CANADIAN INTEREST in atomic energy may be considered to have commenced with the work of the late Lord Rutherford when he was a professor at McGill University. It was during these years, 1898 to 1907, that he and his associates laid the foundations upon which the ultimate release of enormous amounts of energy has now been achieved from nuclear fission of uranium. In this first book on radioactivity, written in 1903, he stated:

"There is reason to believe that an enormous store of latent energy is resident in the atoms of radioactive elements . . . If it were ever possible to control at will the rate of disintegration of the radio-elements, an enormous amount of energy could be obtained from a small quantity of matter."

Sixteen years ago this prediction became a reality with the construction of the first nuclear reactor. This first chain reaction based on the fission of uranium occurred on Dec. 2, 1942, in a room under the seats at the University of Chicago's stadium. It was natural that Canadian scientists, interested in radioactivity since Rutherford's time, should join their colleagues from the United Kingdom and the United States in the intensive work centering in the "Manhattan Engineer District", which led to the atomic bomb and the sudden ending of the war in the Pacific. It is appropriate that Canadians should take particular interest in this new field of nuclear energy, and it should be remarked that the postwar activities have been *exclusively* devoted to the peaceful uses.

The major center of research and development in the field of nuclear or atomic energy in Canada commenced in 1944 with the establishment of the Chalk River Project, administered now by a governmental corporation known as "Atomic Energy of Canada Ltd." Ten thousand acres of marginal sandy land was expropriated on the west bank of the Ottawa River, 130 miles west of Ottawa. Within a fenced area of 100 acres, there are now four reactors in operation and more than 100 laboratories and buildings in which fundamental and applied research in every branch of science dealing with all facets of nuclear energy is carried on with a staff of 2500 including over 400 scientists and engineers. The two large reactors, called NRX and NRU, were designed especially for research. They use heavy water for moderator (to slow the fast neutrons from a split atom down sufficiently for their capture by a uranium atom in the vicinity) and possess experimental facilities unsurpassed by any known reactors.

Both the NRX, which operates at a power level of 40,000,000 w. and the NRU, which develops 200,000,000 w., are provided with outlets from which beams of neutrons emerge into apparatus

*Scientific Adviser to the President, Atomic Energy of Canada Ltd., Chalk River, Ont.

Aerial View of Buildings at Chalk River

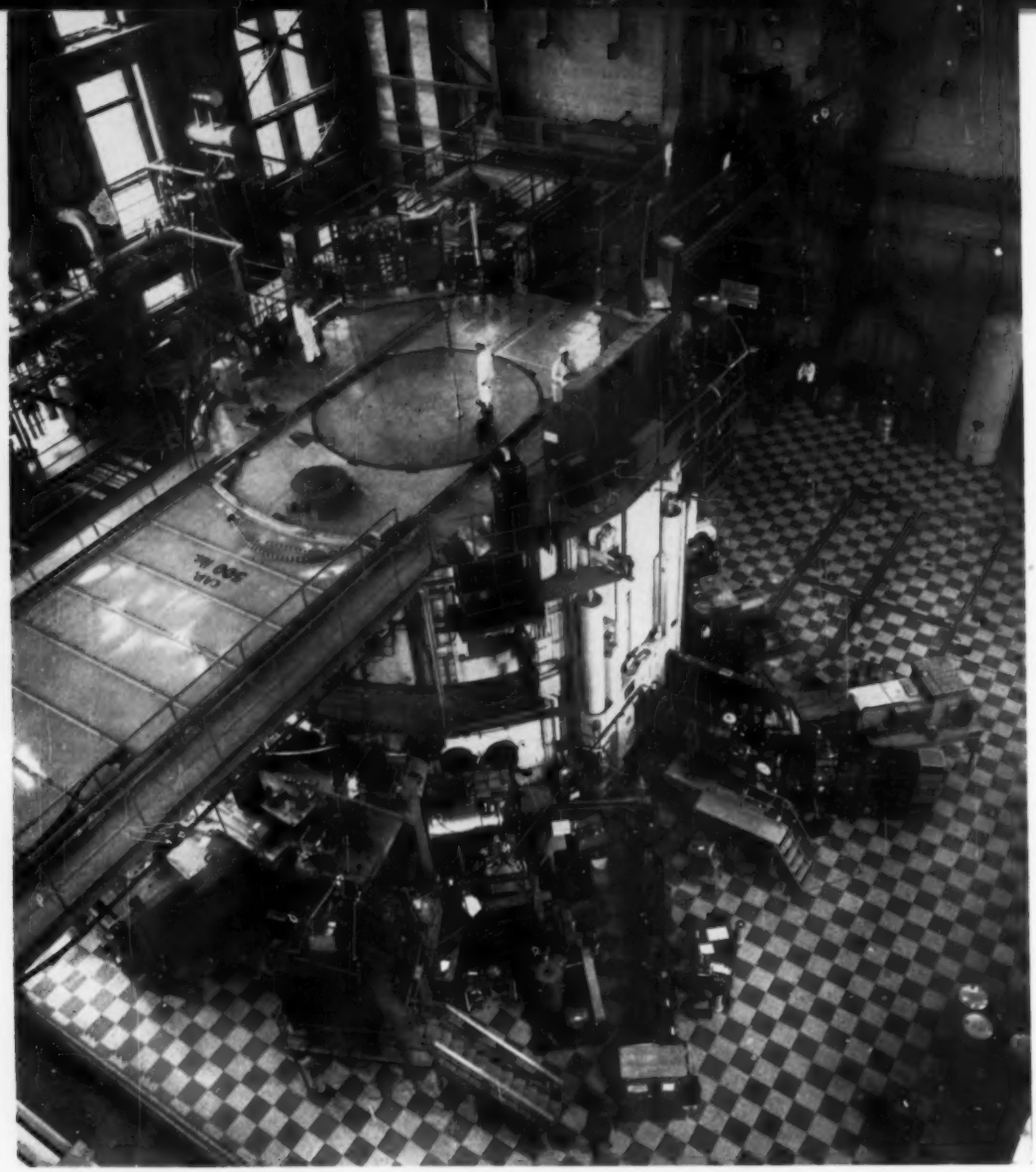
designed for fundamental investigations into nuclear and atomic structure. They also produce isotopes of high specific activity, which are used in various industries, in medical therapy, and for research into a wide variety of problems – agricultural, biological and physical. In connection with isotope production, Canada pioneered the design, production and use of intense sources of cobalt-60 for the treatment of malignant diseases. The commercial products division has sold more than 100 of these units and shipped them to more than 20 foreign countries.

These Canadian reactors have special facilities for making tests on the effect of intense neutron bombardment on various types of nuclear fuel, rods, cladding materials, and corrosion by coolants of different kinds. Such specimens are inserted in tubes called "loops" through which various coolants can be circulated under pressure and raised to 600° F. or higher. The loops pass through the central portion of the reactor and are thus exposed to the same conditions that would prevail in a power reactor. Such investigations are carried on in the NRX and NRU reactors in cooperation with the United States Atomic Energy Commission, the United Kingdom Atomic Energy Authority, and their associated contractors. For example, certain investigations on fuel elements for both the submarine Nautilus and the Shippingport reactor were thus performed in the NRX reactor.

A long article could be written to do little more than list the facilities and experimental programs of the physics laboratories, the chemistry laboratories and the biological and medical laboratories. The metallurgical laboratories study fuel alloys for power reactors; they are equipped with electric furnaces for making various alloys, small rolling mills and swaging apparatus, as well as other instruments for examining microstructure of irradiated specimens in "hot caves".

Need for Atomic Power

Apart from the fundamental investigations which produce the information upon which applications are founded, the main effort at present at Chalk River is directed toward the economic development of electrical power from the heat released in the fission of uranium. The standard of living in any country may be measured by its consumption of power per capita. For example, if the energy released by burning a ton of coal be taken as standard, the power used per capita in the United States is 8.18 tons per year, in the United Kingdom 4.58, in France 2.59, while in India it is 0.35. If the per capita consumption in India were raised to that in the United States, her 40,000 million tons of coal would not last a decade! Or, take another yardstick, electrical power: The demand is doubling every ten years in the more advanced Western countries, and if



NRX Reactor at Chalk River, Surrounded With Equipment for Various Studies Requiring Intense Beams of Energy

the standard of living is raised in the less developed Asiatic countries, and accounting for the net increase in world population, some new source of energy *must* be provided.

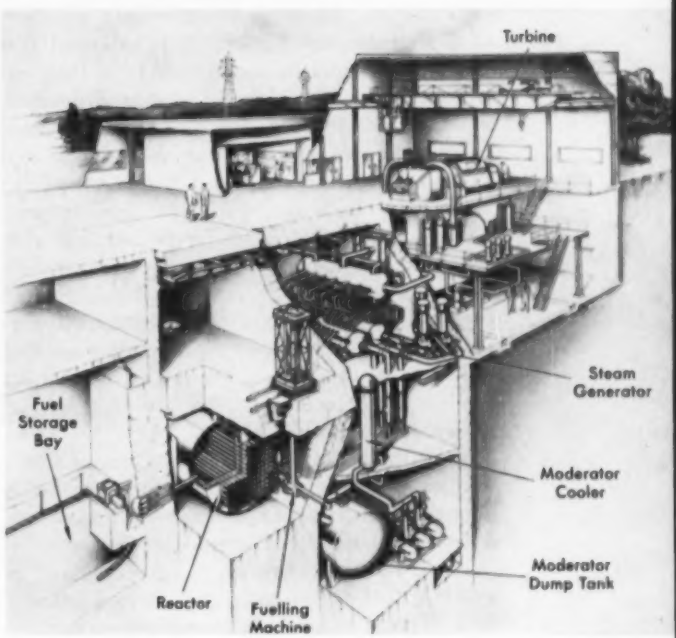
Canada possesses large supplies of fossil fuels, coal in the far eastern and western parts of the country and natural gas and oil under the prairies of the west. The major demand for power, however is in the central provinces – Ontario and Quebec – which have no indigenous supplies of fossil fuels. They do have water falls and rapids from which most of their present supply of energy has been developed in hydroelectric plants. The need is growing at such a rate that by 1961 all such economic hydro sources will have been developed in Ontario, including that from the new St. Lawrence Seaway. Even at present, large coal-fired generating stations are required to meet the demand, especially in the industrial centers of southwestern Ontario. Some economical method of supplying this demand other than by importing coal from the United States (as done at present) must be found. Since Canada has now the second largest known reserves of uranium ore in the world – most of it in the Blind River district of Ontario – it is very natural that special interest should be taken by those working at Chalk River, and by the

Hydro Electric Power Commission of Ontario, in developing electricity from the heat released by nuclear fission of uranium.

It has often been said that 1 lb. of uranium, if completely "burned" in a reactor, would produce as much heat as burning 2,700,000 lb. of coal, or 60,000 gal. of oil, or 20,000,000 cu.ft. of natural gas. We do not know yet how to fission completely a pound of uranium, but we can consume 1% of it in our present reactors. What does that mean to Canada? Last year we used 90.2 billion kw-hr. of electricity, over 91% being hydro, and if this had been produced by "burning" just 1% of uranium and producing electricity at 25% efficiency from the heat, it could have been obtained from 1500 tons of natural uranium metal. It is predicted that Ontario will require by 1980 an installed generating capacity of 22,000,000 kw., of which 16,000,000 will be generated by thermal stations. If the latter is from imported coal at $9.00 per ton, it will cost about $280,000,000 per year. With ample supplies of uranium available (and the metal is now being made in Canada by the Eldorado Mining and Refining Co. at Port Hope), the utility companies are naturally interested in uranium rather than imported coal.

A group of engineers from various Canadian utility companies have spent two or three years at Chalk River working on the design of a nuclear power plant, under the chairmanship of H. A. Smith of the Ontario Hydro. With the assistance of our W. B. Lewis and his staff of scientists and J. L. Gray and his engineers, they have developed a new concept based on our experience with heavy water moderated reactors. It differs from the United Kingdom and the United States atomic energy generating stations both in moderator, coolant, type of fuel, and structure. Instead of using large pressurized vessels and somewhat enriched fuel, natural uranium oxide will be sheathed in zirconium alloy and contained in pressurized tubes of relatively small diameter through which heavy water coolant will pass at about 2000 psi., where it will be heated to 500 or 600° F. and be circulated through heat exchangers to boil ordinary water producing steam for a conventional turbine. The main reactor tank will be filled with heavy water at ordinary pressures, this acting as a moderator.

As a result of this feasibility study, Atomic Energy of Canada Ltd., in cooperation with the Hydro Electric Power Commission of Ontario and the Canadian General Electric Co. Ltd., is



Isometric Sketch of NPD, the Nuclear Power Demonstration Unit Now Under Construction at Des Joachims Near Chalk River

constructing such a nuclear power demonstration (NPD) plant at Des Joachims, about 20 miles above the Chalk River project, where there is a large hydroelectric station on the Ottawa River. The new plant will generate 20,000 kw. of electricity which will be delivered to the Ontario Hydro system. It is not expected that this small plant will be competitive with a coal-fired station, but it will provide experience to Canadian manufacturers and to utilities, and prove its reliability. This plant is expected to be in operation by 1961. Apart from the new idea of using pressurized tubes containing the slugs of uranium oxide fuel, it will be the first generating plant in which the fuel can be changed without closing down the operation. (The NRU reactor at Chalk River was the first one in the world in which the refueling is performed under continuous operation, and this NPD generating station incorporates the same principle.) It will consequently be used at a "base load" plant and will operate at a steady rate. This is the most efficient type of nuclear power reactor.

A nuclear power plant division of Atomic Energy of Canada Ltd. has been set up in Toronto to design a 200,000-kw. electrical generating station on the same principle as the above-described NPD. Ontario Hydro and other utilities are co-

operating in this work by providing members of their engineering staff. It is expected that this station could be in operation by 1965. It is believed that when the research and development costs have been paid and the first station of this type constructed, the second one will generate electricity at a cost per kilowatt-hour comparable with that from coal-fired stations, namely 5 to 6 mills. It is expected that subsequent improvements in technique and design, as well as reduction in cost of natural uranium fuel, will lower the cost of electricity still further, but this depends largely on finding ways of reducing the capital cost, improving the thermal efficiency and extending the operating life of nuclear power reactors.

Since most European countries, and Canada to a lesser degree, depend upon the importation of coal and oil to meet their energy requirements, it is natural that they should be interested in utilizing the vast store of energy contained in small quantities of easily transported nuclear fuel. This is particularly true when uncertainty may exist in the delivery of oil from foreign sources. With the British now generating electric power from nuclear reactors, and Japan, Finland, Sweden and the Euratom group planning to do so in the near future, special interest is being taken in the Canadian approach to economic nuclear power by foreign scientists, engineers and governments.

Since coal is the largest source of energy used in the world and will remain so for many years, and since the United States has ample reserves of it, Americans are mainly interested in constructing pilot plants of various types with a view of determining the most efficient design. The large plant at Shippingport is now in operation and others are being planned by American utility companies, but they will not generate electricity at costs competitive with those operating on fossil fuels in Canada.

The possibility of using nuclear energy for propulsion of ships, which has proved successful in nuclear submarines, is being studied in various countries. For commercial vessels it again is a matter of economics. The special interest at Chalk River in this application is the development of fuel which will be stable and have a long burn-up that can be used in power reactors.

To assist India in nuclear research with a view to raising the standard of living, the Canadian Government under the Colombo Plan is constructing a reactor similar to our NRX, situated near Bombay. A group of engineers and physicists from India spent a year at the Chalk River Project learning to operate the NRX reactor and becoming familiar with its various functions. The Canada-India reactor is being constructed under the supervision of the Shawinigan Engineering Co. Ltd. and engineers from the Canadian atomic energy project.

Educational Activities

Apart from the fundamental and applied research which is carried on at Chalk River, visiting professors and senior and graduate students from our universities may come and work at the Project during the summer vacations. This enables faculty members to use certain facilities available only in our laboratories and also serves as a means of choosing the students for future employment. Groups of high school teachers, science students and industrial visitors are frequently taken on general tours of the reactors and laboratories.

In addition to the work at Chalk River, several universities in Canada have accelerators of different types working on nuclear research. Their professors and advanced students carry out fundamental investigations, many in cooperation with the staff at Chalk River, using their special equipment and isotopes provided by Atomic Energy of Canada Ltd. Many Canadian universities receive financial grants for equipment from the National Research Council of Canada and from the Atomic Energy Control Board, and scholarships are awarded to able graduates in order that such work may be performed. Last year more than $2,100,000 was given in grants to professors in Canadian universities and about $1,600,000 in scholarships by the National Research Council of Canada.

Conclusion

Expenditures on atomic energy projects in Canada are much smaller than those made by the United States, United Kingdom and France, yet in proportion to population and total income the figure is quite comparable. Since our efforts are confined to fundamental research and the peaceful applications, Canadian scientists and engineers have made substantial contributions in both fields. Their long experience with operation of heavy water moderated reactors, and the present interest in developing economic electric power with this new design incorporating the general principles of research reactors that they have built, will help to establish a better world with a higher standard of living for all.

The Institute of Metals . . . Its First 50 Years

By J. C. CHASTON*

First years were spent in establishing and consolidating the research metallurgist's position. Now that the battle for recognition has been won, the Institute is expanding its activities in nonferrous metallurgy. Research is planned in many fields. (A2, A12g)

THE BRITISH INSTITUTE OF METALS celebrated its Golden Jubilee at its recent autumn meeting in Birmingham during the fourth week of September. Technical sessions were held in the imposing new buildings of the Birmingham College of Technology – rapidly expanding with steel and concrete like so many new English centers of training. It is only a short distance from the site of the original Birmingham Municipal Technological School, where the first General Meeting of the Institute was attended by about 150 members on Nov. 11 and 12, 1908.

On such an occasion, it is inevitable that one should turn back to the records of the early meetings and perhaps attempt some assessment of the caliber of those who wrote and discussed the papers before the meetings half a century ago. What would be their reaction to the problems with which we are now concerned?

The technical program of the autumn meeting of 1958 centered around two sessions – one concerned with nonferrous extrusion and one a full-scale exposition of the evidence for dislocations. The discussion on extrusion was largely academic and would certainly have been reasonably well understood and appreciated by the 1908 metallurgist, who would undoubtedly deplore with his 1958 colleague the shyness of those connected with the extrusion industry towards public discussion of their problems. The exposition on dislocations would have been more bewildering – but whether the 1908 audience of metallographers would have understood its full implications better than the large audience of metal physicists which overflowed the lecture theater in 1958 is a matter for personal judgment.

As one turns the pages of early *Journal* volumes, however, one rapidly gains the view that the outstanding change has been not in the skill, ingenuity, and judgment of the research metal-

*Johnson, Matthey & Co., Ltd., Wembley, Middlesex, England.

lurgist, but in the status of the industrial metallurgist. The stenographic reports of the discussions (unpruned and, by present-day standards, unbelievably verbose) are quite unrivaled in the insight they afford, not only into the characters and capabilities of the 1908 metallurgists but into the climate of industrial metallurgy in those days.

In 1908 physical metallurgy was well on the way to becoming an established branch of science. It may well be said to have been set on its feet by the first five reports, published between 1891 and 1902 by the famous Alloys Research Committee of the Institution of Mechanical Engineers. This had been set up on the recommendation of Dr. Anderson, director general of ordnance factories at Woolwich, as a consequence largely of a paper published from the Royal Mint in 1888 by William Roberts-Austen. Having the title "On Certain Mechanical Properties of Metals in Relation to the Periodic Law", this paper dealt with the effects of the additions of about 0.2% of each of 17 elements on the tensile strength and elongation of gold. The results suggested to Roberts-Austen that addition metals which diminish the strength and "extensibility" of the basis metal had high atomic volumes. The line of thought suggested for the first time in this paper was later developed by Hume-Rothery and other workers in metal physics.

Publication of these reports produced widespread and vigorous discussion on the early views put forward by Roberts-Austen and his colleagues. Roberts-Austen himself produced the first freezing point curves of a metal alloy system. He made good use of the techniques of microscopic metallography introduced by Sorby, Martens and Osmond, and was the first to study the effects of heat treatment and composition on alloy structures in a binary system. His work was very quickly taken up and developed by others. At Cambridge University, Haycock and Neville, in 1903, published their famous study of the copper-tin system. They gave a clear picture of the fundamental changes occurring during solidification of solid solutions, and applied for the first time the ideas put forward in 1899 by Roozeboom. In this study they also used for the first time the technique of examining quenched specimens under a microscope to determine solidus temperatures. Apart from these events, the six years preceding the formation of the Institute of Metals from 1902 to 1908 had been a time of consolidation for the new science of nonferrous metallurgy. Roberts-Austen had died in 1902 and the work of the Alloys Research Committee had been handed over to a special department supervised by H. C. H. Carpenter at the National Physical Laboratory. The eighth report published in 1906 had dealt at length with the copper-aluminum system. Meanwhile, in Germany and France a great number of alloy systems had been surveyed in a more or less cursory manner.

Finally, in assessing nonferrous metallurgy in 1908, it must not be forgotten that at the turn of the century a young graduate from Melbourne, Walter Rosenhain, had observed the formation of slip bands on the surface of strained metals, and, in seeking an explanation, really laid the foundation for the whole of the modern dislocation theory.

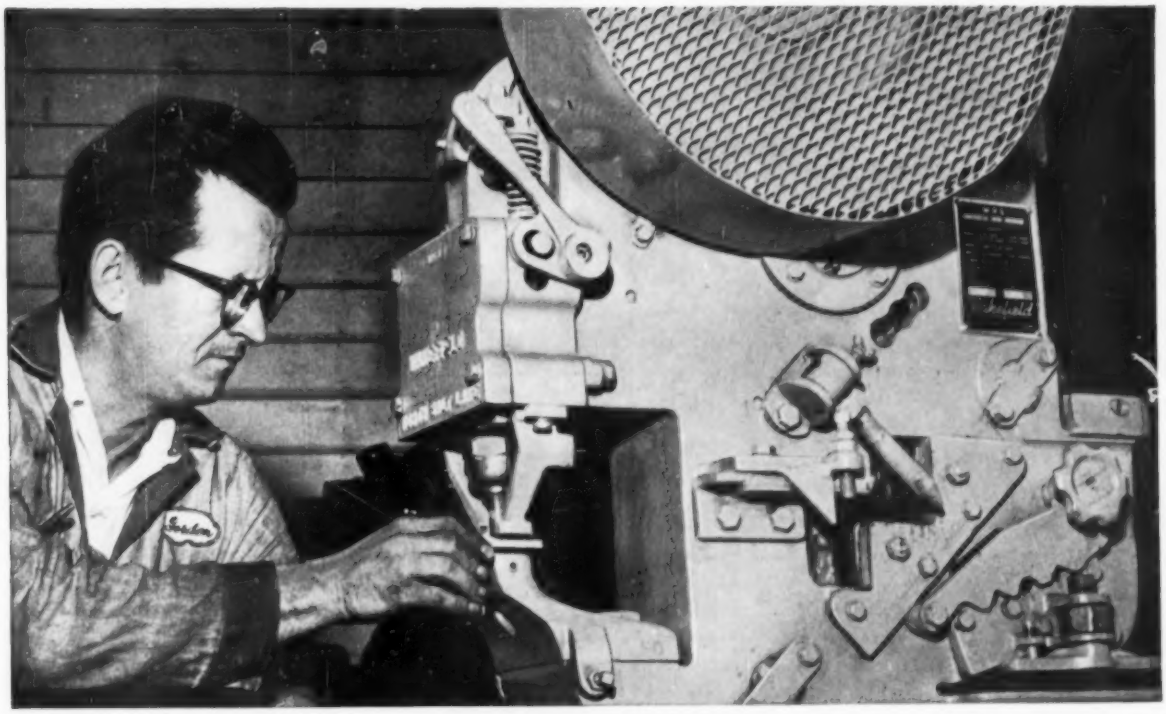
The Original Task

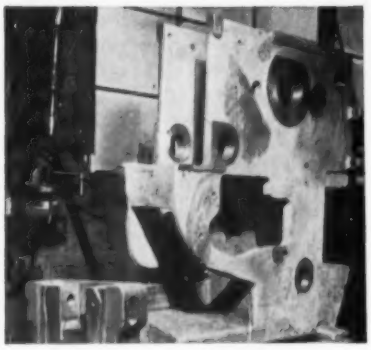
At the time when the new Institute was created, it seems fair to say that nonferrous metallurgical studies mainly centered around engineering and general scientific circles. Industry, on the whole, had been slower to see the application of new ideas to melting, alloying, fabrication and heat treatment. Ascribing this attitude to the tradition of secrecy in these industries, the first president, Sir William White, said "Many firms . . . are not prepared to disclose processes or to permit such inspections as might result in acquisition of information likely to prove of value to potential rivals in business . . . All associations which deal with application of science to manufacture or to various branches of engineering pass through this phase of development as their operations extend. I feel confident that, as the Institute of Metals increases in membership and importance, development will take place." Fifty years later, we may say that this prophecy erred only in being conservative.

Whatever the true reasons may have been, it is certain that in 1908 the works laboratory played a very minor part in the scheme of things. It is even more certain that the industrial research laboratory was virtually nonexistent.

The "lab", as it was usually known, was concerned principally with the routine analysis of alloys for their major constituents, and equipment was kept to a bare minimum. It was not unusual to find jam jars serving as beakers.

In these circumstances, it is evident that those responsible for administering the Institute re-





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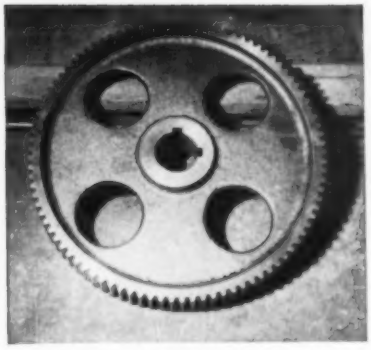

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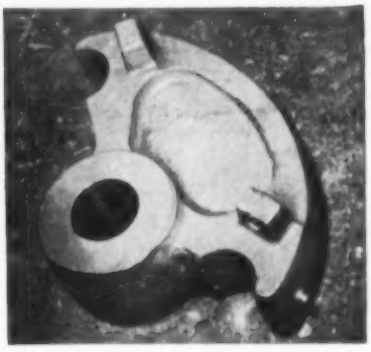

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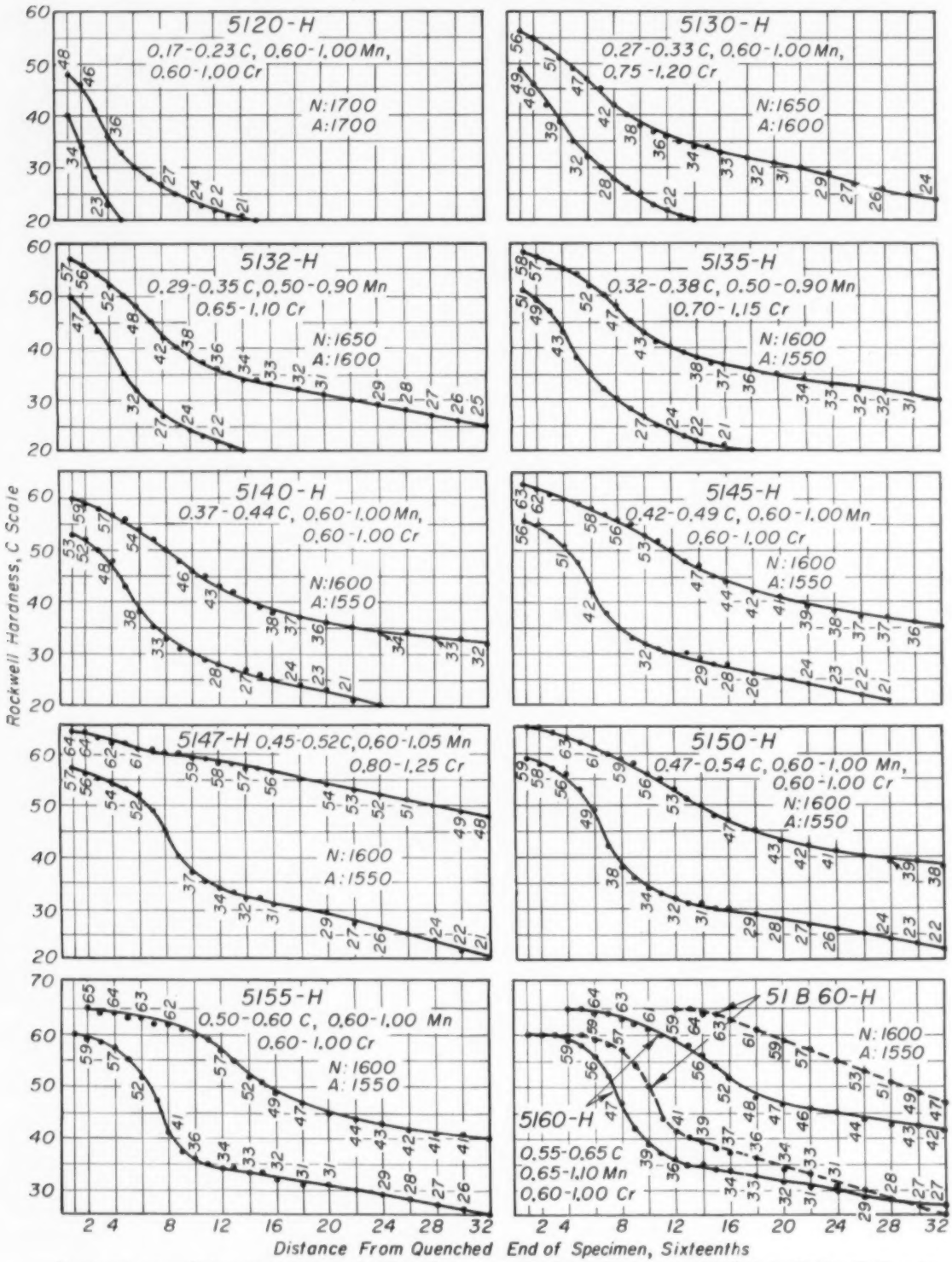

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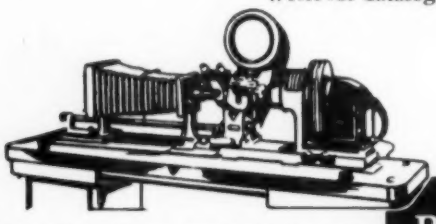

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garded the education of the industrialists as one of their chief aims. Whether consciously or not, it is clear that the procedure adopted was well fitted to serve this purpose. At the time, it was customary to circularize preprints to be read at each of the half-yearly meetings a few days before the meeting. The papers were presented by the authors in considerable detail and were then discussed with a freedom and an enthusiasm we do not always find today. Moreover, the discussions were reported at such length that members unable to be present at the meetings were able to appreciate the arguments and were often encouraged in subsequent written discussion.

These arrangements proved satisfactory for many years, for education of the industrialist was a slow process. As late as 1923, industrialists objected to the fundamental approach to the study of metals. At the annual autumn meeting held in Manchester that year, a team of investigators at the National Physical Laboratory made their first report on the effect of impurities on copper and on the effect of oxygen.

In the discussion, the industrialists' point of view was put by Sir Gerald Muntz. According to him, if the investigators had gone to those people who had been engaged all their lives in handling copper, copper castings, various grades and refinements of coppers, coppers with high oxygen or low oxygen, in fact every class of copper, they could have saved themselves a great deal of investigation. He himself had been in the business since 1883, and at that time he began to make investigations into those high-grade pure coppers. He spent seven years upon that work. He did not publish the results; there was no Institute of Metals at that time to offer a medium for publication, but he arrived ultimately at some conclusions. "Without controlling the oxygen, ductility in high-grade coppers would not be obtained . . ." and so on.

In his reply, Dr. Rosenhain put the case admirably for scientific investigation. "It was in order to test the very things which the practical men thought they knew about copper," he said, "that the investigation had been planned and carried through. Some of the things which some of the practical men thought they knew were not so at all. A certain amount of the practical knowledge which had been so closely guarded as a trade secret for so many years proved to be not really accurate."

It is not too much to say that during the 23 years Rosenhain was at the N.P.L. he was a driving force behind much of the research work on physical metallurgy in Great Britain, and that the Institute of Metals provided an unrivaled opportunity for publicizing his efforts. He published first-class work totaling about 100 papers on every aspect of physical metallurgy, and he initiated and directed many of the outstanding researches of his generation. It is still enjoyable to read such early discussions as that quoted above when he was at cross purposes with industrialists who thought that theoretical people were only finding out information which all practical men knew anyway. Rosenhain would have delighted in Whitehead's description of a practical man as one who practices the errors of his forefathers. Many of those who remember his ability to illuminate any discussion by reference to first principles have felt that since his death at the early age of 55 in 1934 the meetings of the Institute of Metals have never been quite the same. On the other hand, it is also probably true to say that by the time the last great war broke out, the original educational purposes of the Institute had been achieved. There is not the need today for these lengthy reports of discussions of matters of principle.

Its Future Task

The Institute of Metals itself has, of necessity, changed its procedure and has adjusted itself to the changing needs of today. Since the war, a series of important symposiums on various branches of industrial metallurgy has provided an opportunity to bring the latest developments in methods and equipment to the attention of all its members. Except for the discussion in these symposiums, the practice of reporting discussions on technical papers has been largely abandoned. Publications of the Institute today are tending to become a series of records of experimental observations, and are inevitably losing much of the personal touch which characterized the early volumes. In some ways, it would seem that, on reaching its Jubilee, the Institute is pausing to draw breath and consider how best to set its course for the next 50 years. In commencing publication of its excellent series of "Metallurgical Reviews", and in forming, with the Iron and Steel Institute, its powder metallurgy group, it is obviously intending to expand its interests and provide new facilities for its members. In the next 50 years it will undoubtedly serve nonferrous metallurgy as well as it has in the past.

Controlled Atmospheres in Australia

*By F. P. HEARD**

Limited gas sources make the production of adequate controlled atmospheres very difficult, but byproduct propane from newly built oil refineries appears to have solved the problem. An immense pool of natural gas under the Sydney area has also been considered as a potential source for controlled atmospheres. (J2k, B25)

WE ARE a fairly new nation, and our industries are growing rapidly. This growth has continued despite the many problems our limited fuel resources and isolated location bring. One major problem has always been to find a suitable fuel from which a controllable furnace atmosphere could be generated.

In the early stages, most work centered around conventional exothermic city gas generators. The air-gas mixture passed into a combustion chamber, and then through a water tower. This brought its dew point approximately to room temperature, but little was known of the dew point effects. There was some success with medium and low-carbon steels, but higher carbon steels and toolsteels† requiring high hardening temperatures were a different story.

Naturally, improvements were needed. The next stage in development of the exothermic gas generator was to pass the water-scrubbed gas through a bed of alkaline-impregnated wood wool laid alternately with layers of "bog ore" (ferric hydrate). This removed most of the CO_2 and H_2S and provided a suitable atmosphere for copper brazing and bright annealing.

There has always been spasmodic interest and varied uses of an atmosphere generated exothermically from charcoal. Early in World War II, several furnaces used this atmosphere to clean-harden springs. No attention was paid to dew point, but the atmosphere was enriched by benzol and ammonia. Brittle springs were soon encountered (due to nitrogen pickup from the ammonia), but after the ammonia addition was stopped some very excellent results were obtained. This same atmosphere without benzol enrichment was in fairly general use for bright annealing of low-carbon sheet and strip.

The primary metalworking industries have used controlled atmospheres for many years. In the steel industry, atmospheres prepared from coke oven and blast furnace gases have been common, and the copper industry requires prepared atmospheres for intermediate annealing of sheet, strip and wire.

The development of the endothermic generator in other countries, particularly the United States, intensified interest here, but again there was the problem of a suitable fuel. About 1950, McPhersons Ltd., bolt and screw manufacturers in Melbourne, Victoria, installed a furnace to restore carbon on rolled threads. The atmosphere was supplied from an endothermic generator burning city gas; this generator is still successfully in operation. A similar generator was also installed at about that time in a small arms factory for treatment of medium-carbon steel rifle barrels.

A year later we planned installation of a continuous pusher-type gas carburizing furnace in a new plant at Fairfield. We reasoned that, whatever difficulties existed, the Australian gear industry clearly could not afford to be without the economic and technical advantages of continuously operating furnaces.

Although two endothermic city gas generators were then operating, they both operated at relatively high dew points in applications not need-

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†As an interesting sidelight on high speed steel, the author recalls using brown coal briquettes in an electric furnace. These were first dried at about 400° F. on top of the furnace, and then placed in the furnace chamber just before the job. That the amount of volatile hydrocarbon and the amount of air ingress to the chamber resulted in a good surface condition was one of those rare occasions when luck favored the heat treater.

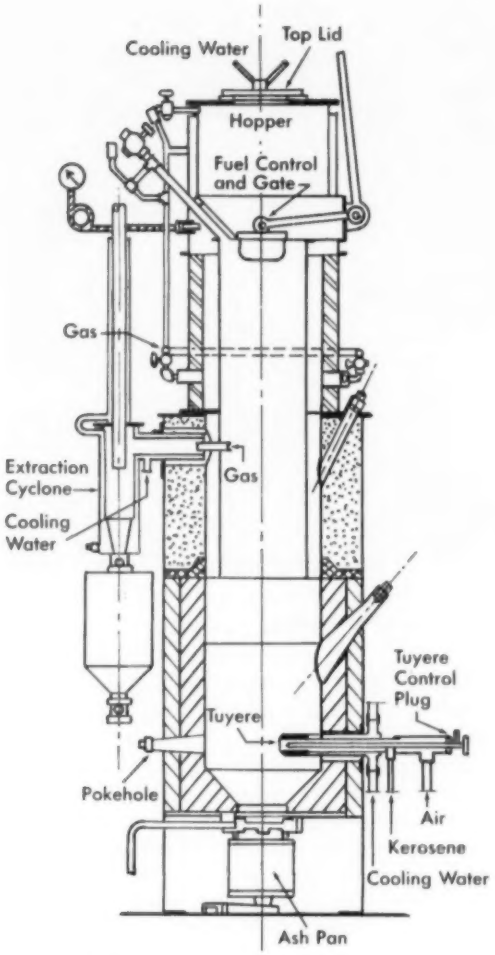

Fig. 1 – General Arrangement of Charcoal Gas Generator

ing a high carbon potential. A study of all available information at the time strongly suggested that the sulphur content of city gas was high enough to cause serious difficulty both in the generator and within the furnace when operating at high carbon potential. Generator catalysts would be rapidly "poisoned", and sulphur attack on heat resisting steel skid rails, radiant tubes, work trays and other parts would result in excessive maintenance cost. Sulphur tolerance in the carburizing process itself was an unknown factor. Experimental work was obviously necessary. A test rig was set up in which the gas, with sulphur reduced to an acceptable level, was reacted with air through a bed of charcoal at 1800° F., but the variable gas composition was discouraging. We next tried an endothermic reaction of power kerosene and air over nickel catalyst, but again the sulphur bogey reared its ugly head. Kerosene with very low sulphur was available from the Palembang area; however, continued supplies from this source were uncertain, so we reluctantly turned back to charcoal.

Continuing their work, Baker and Jonnes increased hydrogen in the carrier gas by adding kerosene to the air stream at the generator tuyere. By further enriching this gas with a light petroleum hydrocarbon, good carburizing conditions were achieved. The generator finally adopted is shown in Fig. 1. It commenced production in May 1954, and has continued with rather mixed fortunes since. When well-devolatilized clean charcoal is available, reasonably consistent carburizing has been achieved, but if foreign matter in the charcoal forms clinkers in front of the tuyere, gas quality deteriorates. The only remedy is to close down and clear the generator. From sheer necessity we have devised ways to reduce these experiences to a minimum; the two main factors have been careful precleaning of charcoal and the use of propane instead of kerosene.

A constant worry has been the heavy deposit of soot which covers the work. This at first was thought to be due entirely to the hydrocarbon fluid enrichment then in use, but the problem was only partially relieved when liquid propane became available. In continuous furnaces, the amount of enrichment needed to maintain sufficiently high carbon potential is increased because air from charge and discharge vestibules dilutes the atmosphere. We have managed, by using a smaller single-track batch-loaded furnace, to produce work with appreciably less soot. However, it does not seem possible with this carrier gas composition (30% CO, 6% H_2, 3% CH_4, remainder N_2, dew point −15° F.) to produce completely soot-free carburizing. Fortunately, the soot deposit has been sufficiently porous and loose to allow good carburizing on the majority of parts, but it is only in recent months – and after many modifications to furnace design and operating technique – that we have been able to gas carburize hypoid gears. Soot deposits have varied enough to cause spotty carburization.

The smaller one-track furnace was originally installed as a reheat furnace for the output of the two-track furnace. It is now quite separate, and is used for light and heavy case carbonitriding and carburizing, quenching of medium carbon and pack carburized parts, and stress-relief annealing.

Fig. 2 – Propane Storage at Melbourne. Eack tank holds 7800 gal. and normally is 80% filled with liquid propane

The previous reference to propane will cause some readers to wonder why it was not used from the start. Well, propane has only become available to us in limited quantities during 1957, since oil refineries within our shores have been operating for a short time.

Quick to seize the opportunity, General Motors-Holdens of Melbourne, Victoria, installed a two-track continuous carburizing furnace and two batch-type carbo-nitriding furnaces with appropriate endothermic generator capacity. Byproduct propane from the refinery is stored in two 7800-gal. tanks from which the generators are supplied (Fig. 2). Early fears that high proportions of propylene in the gas would cause sooting problems have proved unfounded, and work of the highest standard has been produced.

The success of this installation and the growing availability of propane have resulted in a most active and healthy interest in controlled atmosphere heat treatment in this country. We can now hope to use the kind of furnaces and equipment which achieve the results we read about and see so much in American practice.

One of the few large Lurgi gas plants established outside Germany has recently commenced production in the Morwell area in southeastern Victoria. The capacity is about 15,000,000 cu.ft. per day and a typical composition is 53% H_2, 24% CO, 20% CH_4, 2% CO_2, 1% N_2 with little variation. The application of this gas to furnace atmosphere work has received much attention, and very encouraging results have been obtained.

The intense search for oil here has not as yet produced it in commercial quantities. Many wells have produced gas, but they are so far from the industrial areas that no matter how much gas is available, the cost of piping it is a formidable obstacle.

There is, perhaps, some reason for hope in the Sydney area, which is approximately at the center of an immense saucer-shaped system of coal seams. The coal is mined at and near the surface at a number of places some 30 to 100 miles from Sydney. They include Newcastle and Maitland in the north, Lithgow in the west, and Bulli and Wollongong in the south.

Some 2000 ft. below Sydney, the seam appears to contain vast quantities of almost pure methane at a pressure of up to 300 psi. The extent of this pool is now being surveyed by the Australian Oil and Gas Corp., and an American drilling team is doing an intensified drilling program. The possibilities are indeed exciting. If all goes well, we may be able to tap gas from the earth beneath the furnace itself.

These developments have greatly interested the Australian heat treater in the use of controlled atmospheres and whenever a new heat treating plant is planned, this modern equipment is the first consideration.

Principles of Eddy Current Testing

*By FRIEDRICH FOERSTER**

This versatile method of nondestructive testing is becoming more and more useful by the day. A defective sample will cause the impedance of a test coil to vary; these variations can be measured to determine several properties such as hardness, tensile strength, diameter, conductivity and permeability. (S13h)

ORIGINATED in Germany before World War II, eddy current testing has in the last few years become widely known as a versatile method for nondestructive examination. Instruments can locate defects, both surface and subsurface, with ease. Adjustments also enable the same instrument to detect variations in diameter, grade, tensile strength and hardness, and often a quantitative determination is possible. Since eddy current testing can be adapted to measure any, or all, of these variables, it is likely to be a valuable addition to any inspection setup. Furthermore, as automatic production lines become more common, nondestructive in-line testing will become essential to control the quality of both the material and the finished part.

The principles of eddy current testing are quite complex, but have been fully worked out since origin of the method 20 years ago. Essentially, the instrument measures the impedance of a coil. In turn, this impedance depends upon the physical properties of the material within the coil, the current frequency, and the electrical coupling between the coil and material. To begin with, we test a nonmagnetic rod which completely fills the test coil. Theory and experience show that the impedance varies as shown in Fig. 1. On this curve the abscissa values are given in terms of normalized resistance $R/\omega L_0$ and the ordinate values are in terms of the normalized reactance $\omega L/\omega L_0$ where R and ωL are resistive and reactive components of the test coil impedance with the sample inserted and ωL_0 is the reactance of the empty coil†.

The test object has a characteristic frequency f_g which is given by the formula

$$f_g = \frac{5060}{\sigma \mu d^2}$$

where σ is the conductivity in m. per ohm per sq.mm. and d is the diameter of the rod in cm. (It is assumed that the resistance of the empty coil is negligible.) Points along the curve are marked at various values of the ratio of the exciting frequency to the characteristic frequency of the test object, or f/f_g.

Since f_g decreases as σ increases, the ratio f/f_g must increase with increasing σ. If the ratio f/f_g is unity for a particular rod in the coil, then the coil impedance will be represented by the point marked 1.00 on the curve. If the rod is now replaced by one which is identical to it except that the conductivity of the new rod is four times larger, the impedance of the coil will be represented by the point marked 4.00. The change in coil impedance will change the magnitude and phase of the voltage across the coil. Either or both of these changes can be detected.

If the rod does not completely fill the test

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†It is important to remember that the impedance is the vectorial sum of the resistance and the reactance. Instruments can be designed to measure any or all of these factors; this is the feature which makes eddy current testing so versatile.

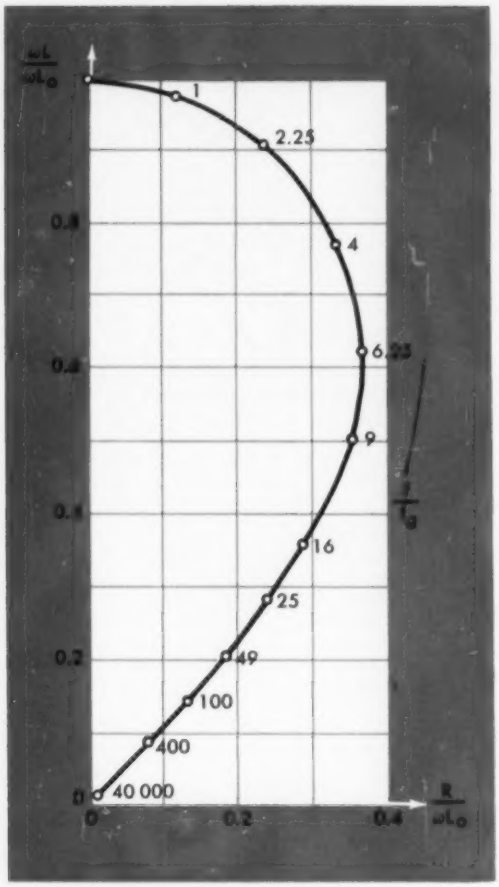


Fig. 1 – Impedance Curve of a Test Coil. This particular curve applies to a coil filled with a nonmagnetic object

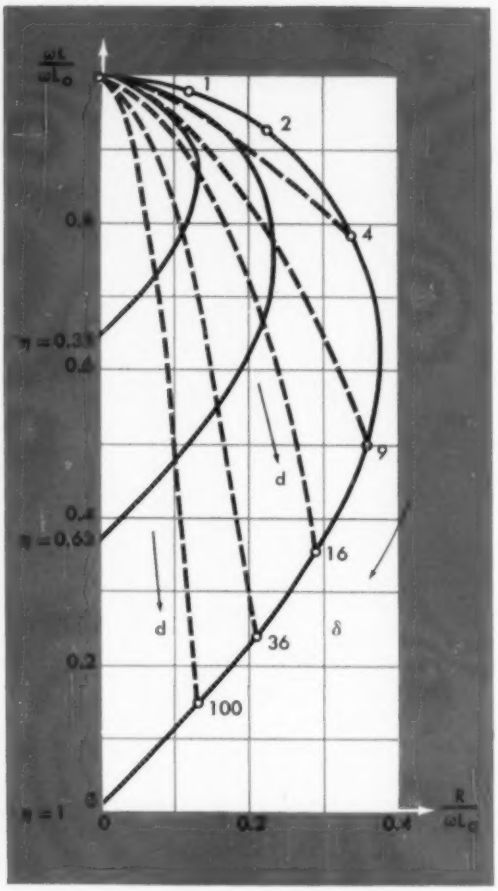


Fig. 2 – Impedance Curve for Various Fill Factors. Dashes connect points representing coil impedance when only change is in diameter

coil, the coil impedance will vary as shown in Fig. 2. The ratio of the cross-sectional area of the test object to the cross-sectional area of coil is called the fill-factor, or η. Figure 2 gives the test coil impedance curves for various values of η; the curve $\eta=1$ is the same curve shown in Fig. 1. The change in voltage produced by a change in diameter differs in phase from the change in voltage caused by a change in conductivity. Thus, phase-sensitive circuits can distinguish between changes in dimensions and changes in conductivity.

Magnetic Material

In Fig. 3, the normalized impedance for the test coil ($\eta=0.5$) is given for various values of permeability, conductivity and diameter. Along the curve corresponding to a permeability μ of 100 gauss per oersted, values of f/f_σ are marked. The dashed curves join points representing coil impedance when the only change is a change of permeability. For magnetic materials, a change in diameter causes an impedance change in the same direction as that caused by a change in permeability. Conversely, for low values of f/f_σ, the change in impedance resulting from conductivity change is about at right angles to the change caused by a permeability variation. In this range one can distinguish between permeability and conductivity effects.

Cracks

The data for impedance changes caused by cracks, both surface and subsurface, were obtained empirically. Artificial systems, constructed of mercury-filled cylinders with plastic rods for "defects", were wrapped with coils, and impedance measured. The changes vary widely; they depend on the system's f/f_σ ratio.

The point marked A in Fig. 4 represents the coil impedance when the coil contains a good sample. If the sample diameter is decreased by

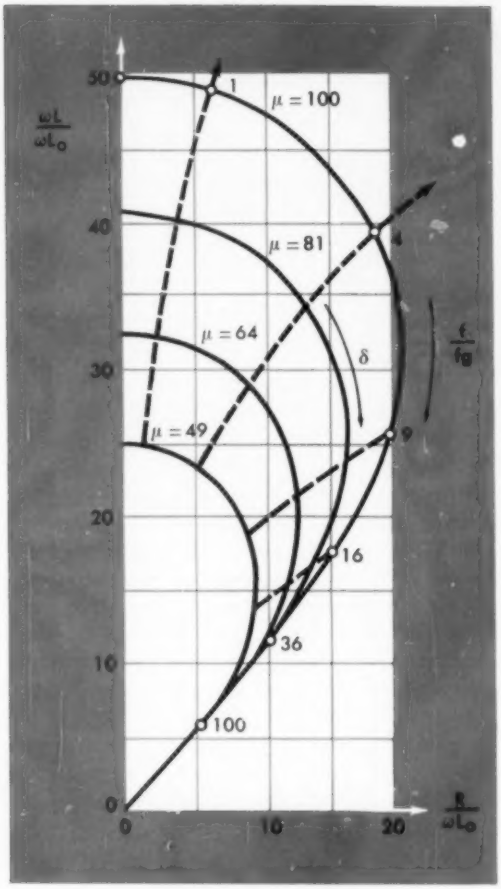


Fig. 3 – Impedance Changes in Magnetic Materials. Various values of conductivity, permeability and diameter are included

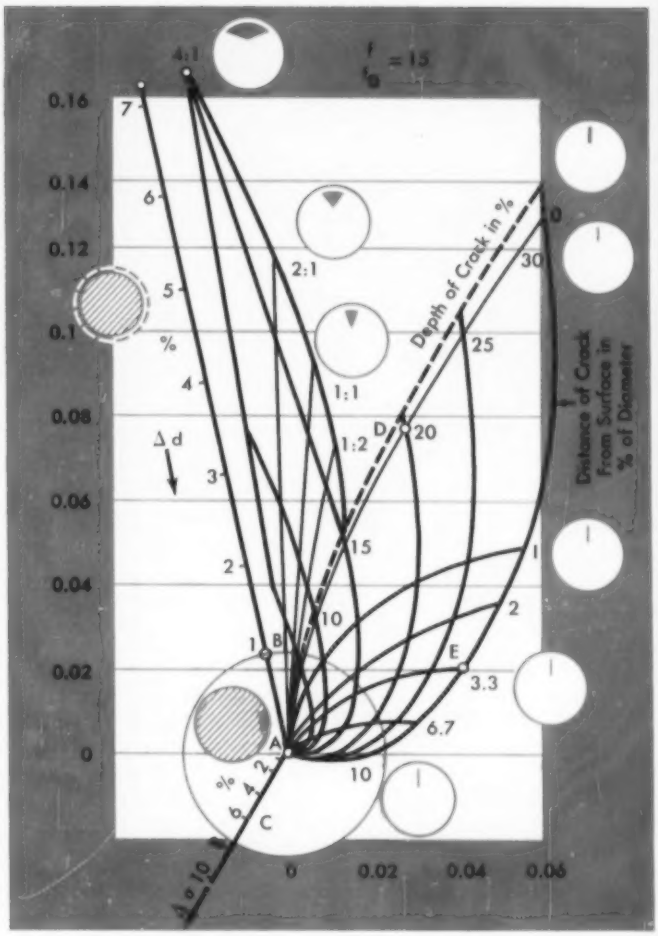


Fig. 4 – Impedance Variations Caused by Surface and Subsurface Cracks ($f/f_g = 15$). Other factors shown are described in text

1.0%, the normalized impedance moves to B. Larger diameter changes cause the impedance to continue in the same direction; a line indicating the direction of these changes is marked in per cent. If, on the other hand, the conductivity should increase by 5.0%, the impedance will be represented by C. Here, the line marked $\Delta\sigma$ indicates changes in conductivity.

The impedance change due to longitudinal surface cracks are shown in this figure by the curve marked "Depth of Crack in %". Thus a crack having a depth equal to 20% of the diameter will cause the impedance to move from A to D. The curve marked "Distance of Crack From Surface in % of Diameter" delineates impedance changes for subsurface cracks. For example, a thin crack located 3.3% below the surface and having a depth of 30% of the diameter would cause the impedance to change to the point E. The remaining curve on Fig. 4 illustrates the variation in coil impedance for V-shaped defects whose ratios of width to depth are marked.

To illustrate the need for phase-sensitive circuits, the large circle (center at A) gives the necessary per cent change in each of the three variables (diameter, conductivity and defects) to cause the same change in the magnitude of impedance. For example, a 1.0% change in diameter produces the same change in the magnitude of impedance as a 7.0% change in conductivity or a 5.0% depth surface crack. Without the correct circuits, it would be impossible to tell which variable was affecting the impedance.

The curve of Fig. 4 was based on an f/f_g of 15; impedance values would be different for other f/f_g values.

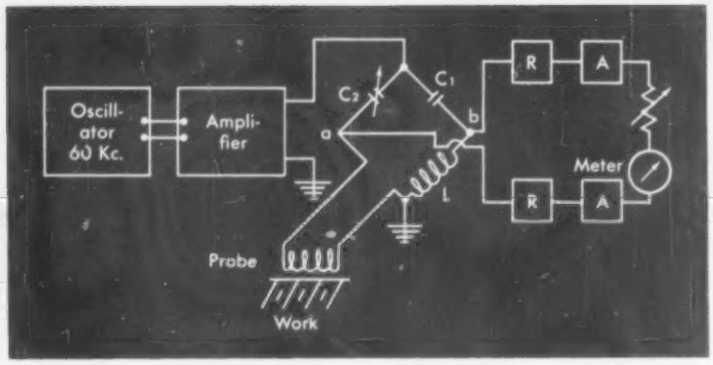


Fig. 5 – Block Diagram of Probe-Type Instrument

A study of Fig. 1 through 4 shows that the frequency required for a particular nondestructive test is governed by the type of defect, its location in the object, the conductivity of material, and its diameter. For general crack detection, a value between 5 and 15 for the ratio of f/f_g is best.

Since the information concerning the test object appears as a *change* in the impedance of a test coil (rather than in the actual impedance), it is usual to use two or more coils connected electrically so that the impedance changes are detected. Two coil arrangements are common. In both, two coils are connected in series opposition such that the combined voltage output is zero when both coils are empty. The setup can be likened to a Wheatstone bridge. In the "absolute coil" method, a good test part is placed in one coil and the object to be tested is placed in the other. Obviously, if the second object is also good, the combined voltage output will be zero. If not, the impedance of the two coils will be different, and the difference will be measured by the output voltage.

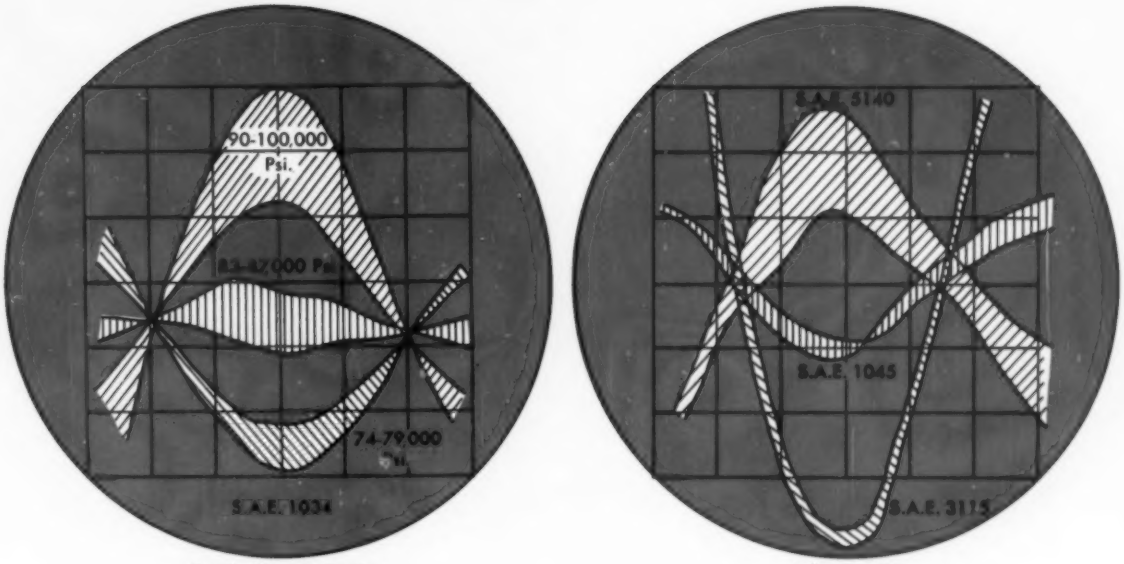
Fig. 6 – Production Instrument for Magnetic Material. One coil holds a good sample; when there is no voltage variation the tested sample is also good

In the other coil arrangement (the differential method), two coils are lined up coaxially so that the object to be tested goes through both. Thus, sections of the same object – a long rod, for example – are compared.

Since diameter changes and alloy changes (conductivity, permeability) usually take place slowly in wires and bars, the differential coil arrangement has low sensitivity to these changes. However, the setup retains normal sensitivity to any change affecting only one coil, such as a short crack or the beginning of a long seam. This permits great amplification and consequently great sensitivity to short cracks. Of course, when diameter and alloy changes are the qualities for which the test is being made, then the absolute coil arrangement must be used.

Coil Types

Two general types of coils are in common use. One is a circumferential or feed-through coil through which the test part passes. The second is a small coil which can be placed on the surface of the part so that its axis is perpendicular to the surface. This is called the probe coil.



Tensile Strength Sorting

Alloy Sorting

Fig. 7 – Typical Test Patterns Produced by Instrument Shown in Fig. 6. These machines can also detect variations in hardness, conductivity and diameter

Figure 5 is the block diagram of a probe-type instrument. The sensing coil is placed on the work and the balancing coil is fixed within the instrument housing. Units of this type are used to sort mixed stock, measure hardness (where hardness has a one-to-one relation to conductivity), and determine thickness of conducting and nonconducting coatings. They can also be used as defect detectors.

Instruments employing feed-through coils can be used for alloy sorting, hardness and tensile strength measurements, conductivity measurement, and dimension controls. Other adaptations also enable such units to detect defects and eccentricity, and measure plating thickness in tubing. An instrument designed particularly for magnetic materials is shown in Fig. 6. This unit uses a cathode-ray tube which presents the information as a distorted sine wave. Figure 7 illustrates its signal when used for alloy and hardness sorting. A modified version has been applied to control heat treatment of spring ribbon. The continuous ribbon passes through the measurement coil after leaving the heat treat oven; the cathode-ray trace controls the oven temperature.

Metal Cutting Problems

At present, eddy current techniques are useful for assuring that metal stock intended for sawing or machining meets the required specifications. Important today for automatic machining operations, this will be still more vital in the future. For such operations, the hardness must be held within tolerances. A single piece which is too hard may damage the tool and result in many defective parts before the damage is discovered and the tool replaced. Eddy current methods can sort the bar stock by alloy (and often even by heat) so that initial machining operations can be uniform. Intermediate heat treating operations can be adjusted to produce uniform hardness. If necessary, an eddy current hardness test can be carried out.

Future instruments could be designed as an integral part of the machine tool. It would

1. Measure the hardness, check the result against the specification, and reject the part if out of tolerance.
2. Monitor the part for cracks during machining, stop the operation and reject the part if cracked, and reset the machine for the next part.
3. Measure the depth of the cut by means of a coil preceding the cutting tool and another coil following the tool and check the result against the specification, adjusting the tool if necessary.
4. Compare the dimensions of the part at the end of the operation against a standard, and pass or reject the part.

In conclusion, let it be said that the ideal instrument described above does not exist today. However, the components do exist and there is no theoretical reason why the ideal instrument cannot be realized.

A Model of the Sputnik Was a Popular Soviet Exhibit at the Atoms-for-Peace Conference in Geneva (Photo by R. H. Aborn)

More Atoms for Peace

By JOHN P. HOWE*

Discussions at the Geneva Conference indicated that the knowledge of fundamental physics is more advanced than the ability to harness the atomic forces to desired ends, and that work in the latter field tends to be on *ad hoc* problems and is scattered and thin rather than concentrated and deep. (W11p, P18)

IT IS SCARCELY POSSIBLE to discuss the Second Conference on the Peaceful Applications of Atomic Energy held in Geneva, Switzerland, during the first two weeks in September 1958, without comparing it with the 1955 conference. The setting was the same. It was organized and carried out in rather analogous fashion. Even though it came almost a month later in the year, the weather was similar. Many of the same faces were present, but the total number of participants was considerably greater. Herein lies one of the large differences. The second conference had too many participants, too many papers, too many sessions. Perhaps its largest significance was the indications of trends, the opportunities it offered for estimating rates and directions of progress in various parts of the world, and the demonstration that many people around the world have a better appreciation of the large amount of hard work that is required to realize the great benefits forecast at the first conference.

The major premise of both conferences was the same, and was reiterated by the several opening speakers. Simply stated, the premise is that man needs increasing amounts of energy to help him with his work, and the atom can provide this energy in very large quantities. It is observed that the countries with the highest standard of living use the largest amounts of power per person, and it is asserted that power is a major source of wealth for all countries. An inexhaustible supply of energy from fusion was noted by many, and the assumption tacitly accepted that fusion power would be available within their lifetime. (An assumption more acceptable to the writer is that it will be available by the time it is needed by those with the ability to develop it.) The declassification of information on *thermonuclear* reactions was the newsworthy highlight of this conference, just as the declassification of in-

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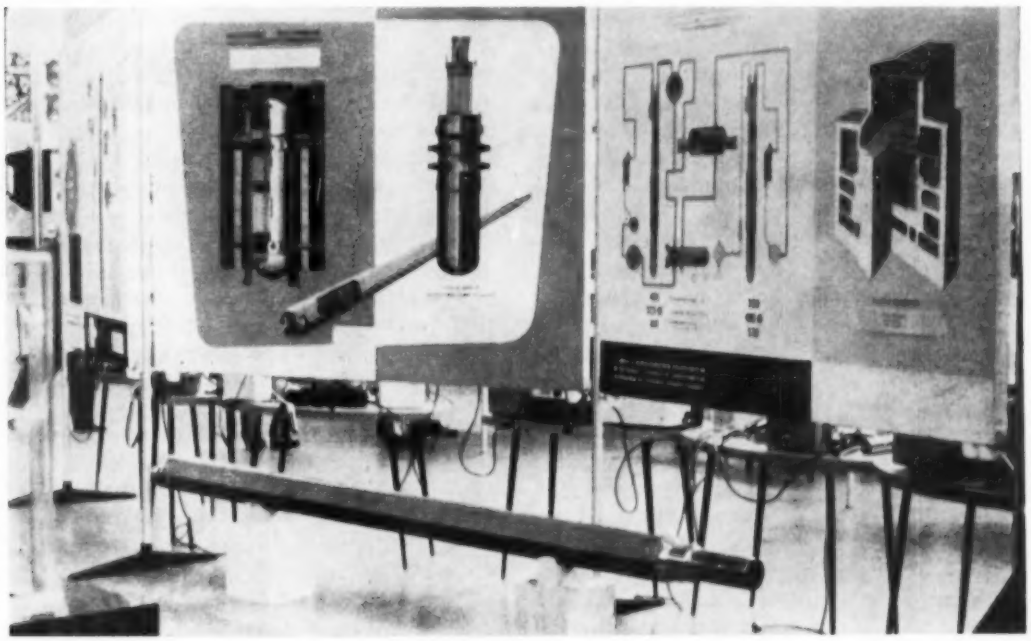
formation about *fission* energy was of the previous one.

In his opening speech, Dr. Perrin, president of the conference and director of the French Atomic Energy Commission, offered the following thoughts: The large industrialized countries – the United States and U.S.S.R. – need only to prepare for future use of atomic energy, since they now have ample supplies of fuel. In Europe, expansion is limited by the availability of power; hence, atomic energy is needed now. The less well-developed countries need to go through a preliminary phase before using atomic energy. For them importing fuels is best until they develop a need for power plants of the order of 100 mw. Training programs are needed currently. President Eisenhower deserves credit for proposing these conferences with the expressed hope that they would lessen the danger of nuclear war. Secrecy in science is a breach of a human right.



Part of Exhibit by U.S.S.R., Showing Fuel Elements for Pressurized Water Reactor and Diagram of Gas-Cooled, Heavy-Water Moderated Reactor

The Fields Covered

The daily sessions were divided into six series, running for the most part in parallel fashion, thus forcing one to make cruel decisions as to where he would listen. The preliminary general sessions contained a distillation of what were probably considered by the organizers of the conference to be the larger topics. Included was some clairvoyance as to what nuclear power would do in various parts of the world; an opportunity was given for each country to brag about what it had done in nuclear power to date and their plans for the immediate future; some guesses were made about what would be done with controlled fusion in the next two decades or so; some assurances given that health and safety are not impaired by the operation of nuclear reactors – in fact, less than by many other more familiar and widespread human endeavors; some imagineering done about uses of nuclear energy in application other than generation of electricity, for example in ship propulsion and earth moving; an appraisal made of recent developments in fundamental physics; and finally ways in which international cooperation has come about in the nuclear field were described.

Metals and Materials

Those sessions which probably are of most interest to readers of *Metal Progress* started with discussions of the supply of raw materials, particularly uranium and thorium, took up the treatment and the occurrence of ores and ways

of locating and obtaining them, and then spent eight half-day sessions on processing the primary materials used in the preparation of reactor components, their basic properties, the properties relative to their use, and how components, particularly fuels, are fabricated from them. The general picture will be summarized by weaving in the importance of materials with information from the reactor sessions, to the extent this reporter is able.

The main objective of the work in metals and materials is to provide substances and a knowledge of their behavior so that fission reactors and their associated equipment and processes can be built and will be worth their cost. (Similar considerations of materials will doubtless come about in the thermonuclear field in the future.) A second reason is to acquire increased knowledge by studying new systems and new phenomena introduced by nuclear reactors. For example, studies of the effects of radiation on matter, and of the transformation metallurgy of uranium and plutonium-base materials, will enrich our knowledge sufficiently to be, in the long run, of equal importance to the more immediate objectives. Thirdly, some of the phenomena (and the measurement techniques such as neutron diffraction used to study them) are increasing our bag of tricks which deal with everyday materials.

This conference was strong in its dealing with fabrication, testing and other details of actual reactor components, but (with certain notable exceptions) rather weak in respect to the second objective, and moved only slowly toward achieving an applied science of nuclear materials.

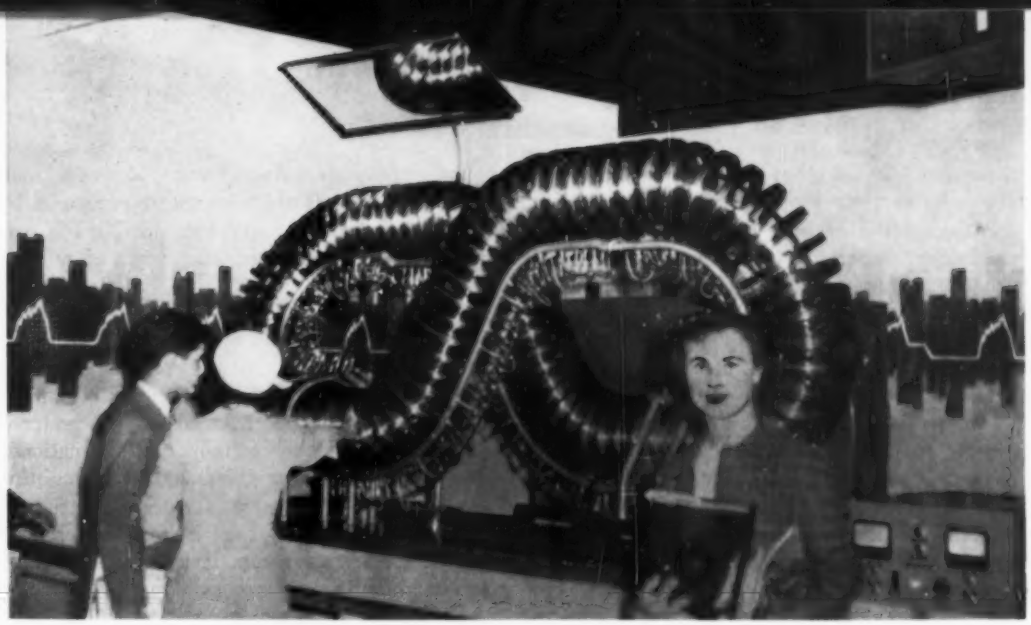
If one looks over all the papers about materials, the general picture can be seen. The United States has programs along nearly every line which promises a useful application of fission energy; thus, our program is broad. In some areas there is adequate depth consistent with the sophistication of the problem involved in the application. However, we are rather prone to assume that once we have thought of a practical objective we have only to scale up and spend money to reach that objective. Either we are too impatient or, in many instances, we do not have the imagination to seek an answer on a laboratory scale to those crucial questions which can appropriately and efficiently be answered in this manner before going on to the more expensive development programs. We are inclined to provide only for tests which we think will show how to achieve the design concept.

National Programs – The program in the United Kingdom also includes an analysis of just about every reactor application. It differs, however, from the American program in that the large-scale effort is concentrated on relatively few systems which have been demonstrated both by analysis and experiment to be the best for the United Kingdom. One has to admire the depth of this program, and gets the feeling that the British understand what they are doing the best of anyone. Two weaknesses of their program are apparent, however: The laboratory work often does not answer the crucial question, and hence judgments based on it are not always valid; and secondly, there is considerable frustration on the part of the workers in seeing their studies of promising systems set aside so they can proceed to analyses of another system.

The program in Canada is definitely concentrated along one line, as will be noted from the system under development there, namely the D_2O-moderated power reactors. Again, their program philosophy is rather like that of the United Kingdom.

In France, the program philosophy is much the same except that the program started later and is not yet so large. Also it must be borne in mind that the French and the British have been as interested in producing plutonium as in power itself. Analysis and experiment on reactor systems to accomplish both of these objectives simultaneously have been excellent. In metallurgical research, fabrication development and related activities, the techniques used by the French are particularly noteworthy, sophisticated, imaginative and painstaking. One might suspect that their understanding of what they are doing in the metallurgical field (at least by the time it is translated into English) is not very comprehensive were it not that the principles of heat treating uranium alloys, for example, have not escaped them.

The program in the U.S.S.R. bears a strong resemblence to that in the United States. Nearly every reactor type which is being studied by us seems also to be under study by the Russians. In fact, one not now underway here was mentioned, namely the use of UF_6 as a source of fissionable uranium. This reactor concept was studied in the United States in the early 1940's but has received little attention since then. There is evidence for a great deal of work in materials in the U.S.S.R. which appears to be highly directed and strong along conventional metallurgical lines, and on the application of radio-isotopes, but it



Model of Figure-Eight "Stellarator" Used in the American Research Program for Controlled Nuclear Fusion

does not appear to be founded on great scientific depth. Subsequent to the conference, Emelyanov did indicate to the writer that he felt the U.S.S.R. needed stronger work in solid-state or metal physics, together with a closer connection between this work and the more practical metallurgy. The same can be said of the United States, but the guess is we have made more progress in this respect.

Western Germany is just getting underway in the nuclear power field. However, in the materials field, for example the preparation of uranium carbide fuels and high-density graphite, one can already see evidence of the thoroughness and scientific sophistication with which the Germans tackle practical problems.

A large number of other countries around the world are now clearly making use of the basic knowledge in reactor materials which has been published and are proceeding to work out those special problems which are important to them. While a quick look at the papers contributed to the Geneva conference by countries such as Norway, Sweden, Denmark, Argentina, Italy, India and a few others suggests that their research is rather narrow, specialized and piecemeal, more thorough study indicates that the problems are well chosen to fill in the gaps in the picture.

Lest we forget that there are still problems in conventional parts of power plants, one might mention the accident at Calder Hall in which a steam turbine blew up due to the rupture of a blade. In this accident, which had nothing to do at all with the nuclear part of the plant, a flying piece of the turbine badly ripped the pants of a worker without injuring him. The man presenting the paper credited this event as being the nearest thing to a genetic effect in nuclear energy to date.

Thermonuclear Power

The behavior of highly ionized gases (plasmas) in strong electric and magnetic fields and at high temperatures occupied five half-day sessions. Combined with this were sessions on the more sophisticated areas which occupied the attention of the pure scientist. Although behavior of the lightest nuclei suggests the possibility of achieving fusion energy, just as that of the heaviest suggested fission power, nevertheless knowledge about nuclear physics is not the bottleneck in either. Thus, the central problems in fusion research are the ways of arranging electric and magnetic fields to confine and heat the plasmas and the instabilities which occur because the plasma itself is usually the conductor which plays a major role in the magnetodynamics of the system as well as the material which is being heated.

Physicists in all countries are aware of the major possibilities. Those countries with the larger programs, namely United States, United Kingdom and U.S.S.R., are covering very much the same possibilities in their work, with variations in emphasis on different techniques or conditions. To date the materials already developed for high-energy electrical capacitors, electrical conductors, electrical control and measurement systems, and for high-vacuum systems have been used. Undoubtedly, improved or new materials will in the long run contribute to progress in the

thermonuclear field, but only a little work is as yet underway.

Although the present writer is not one who thinks that power from the fusion of heavy hydrogen is going to be achieved in the near future, he must repeat that the American display on controlled thermonuclear apparatus thoroughly stole the show (the scientific exhibits at the Palais des Nations). Each of the several ways of producing, confining, and compressing, or heating plasmas was demonstrated by working apparatus or by models which explained the different electrical and magnetic principles employed. An item remarked upon as often as the apparatus was the corps of attractive guides who could explain the intricacies of the apparatus to any visitor in any of the four principal languages of the conference. These girls were all language students from schools for interpreters who had been given an intensive course in science.

Fusion research was also illustrated in the exhibits of other countries, but not in the complete fashion employed by the United States. The British program has centered around the toroidal pinch apparatus. The Russians exhibited only the pinch apparatus.

Personal Contacts

Just as in Geneva three years ago, exchanges of opinion outside the meeting room were most important. For example, Meerson of the U.S.S.R. very kindly conducted Finniston of the United Kingdom and the writer through the Russian exhibit, clearing up some of the metallurgical points in exchange for similar treatment from us.

Finniston was, very kindly, host to a small gathering of metallurgists at his apartment where Bochvar, Meerson, Pravduk and Sergeev of the U.S.S.R., Finniston, Murray, Lloyd and Frost of the United Kingdom, Lewis of Canada, Alder and Meyers from Australia, and Chiswik, Shapiro and the writer from the United States attempted to reach a better mutual understanding of radiation effects in fuels (the most critical current problem), of Bochvar's work on thermal cycling using a variety of metals in which he produces large effects, and of some of the transformation metallurgy in uranium. Of necessity, English was the language spoken, and we could be thankful that the English of the Russians was at least better than our Russian! This party confirmed the notion that the work in atomic energy in the U.S.S.R. in materials is excellent and thorough, but is based on rather less than thorough understanding of the observed phenomena in terms of atom movements and structures. However, such points are difficult to communicate even with no language barriers present. A small laugh was had over a translation of "disordered alloy" into "disorderly alloy".

Summary

Some conclusions and a moral might be offered: Although this conference was organized primarily by scientists, nevertheless the protocol and officialdom which accompanies international dealings tended to be dominant. It is doubtful that the exchange of scientific information is best handled in this way, and future conferences might be broken up into the several disciplines and handled by experts in each field.

The American contribution was large and impressive. As mentioned above, in the thermonuclear field it was stupendous. Perhaps we should worry somewhat about the impression we create in the minds of foreign reactor specialists; namely, that we have spread ourselves widely but do not always thoroughly understand what we are doing. There are good reasons for narrowing our efforts, but there are many reasons for deepening our understanding in the major lines that we are following. Moreover, we must set up more efficient ways of initiating new ideas and evaluating them at the laboratory stage by well-planned, efficiently conducted and controlled studies. In the thermonuclear field we would do well to realize that we may have created the impression that fusion power is much closer than it probably is. Although we were very careful to be cautious on this point, nevertheless the very magnitude of our display and the overwhelming persuasiveness of it is likely to create the above impression no matter what we have said.

Finally, through such conferences, scientists and engineers must find ways of doing more than just impressing people with our cleverness. The next step is to establish confidence in us by the nonscientific world, first, that we can manage our own affairs and, second, that we have more to contribute than gadgets to lighten peoples' labor or power of destruction. The conference did illustrate clearly that scientific knowledge – and probably knowledge in general – is a strong binding force between peoples, providing both a medium and a reason for their cooperation. At least this can be affirmed: None of the forces which are opposed to the intellectual approach, the use of knowledge, and the cooperative efforts were in evidence at this conference.

Metallurgical Fuel Developments

Main Lines of the Postwar Years

*By D. W. GILLINGS**

Extensive blending of high-volatile coal with first-grade coking coal has enabled the supplies of acceptable metallurgical coke to be maintained as needed in Europe. Many British openhearths have been converted to oil firing practice for some years, while the adoption of electric melting for producing plain steels results from efficient power generation from low-grade coal. (D-general; RM-j, RM-k, RM-n, 16-61)

THE YEARS since the end of World War II have certainly witnessed a greater increase in production of goods and services than any equal period. This has been reflected in the heavy demand and unprecedented consumption of primary raw materials. In the metallurgical industries, this goes back of course to the initial smelting operation and particularly to the metallurgical fuels. This has been one reason for the wider interest in fuel and all its applications. For example, the importance of coking coal is now understood by many in industry who in the past never knew that fuels of such special properties even existed!

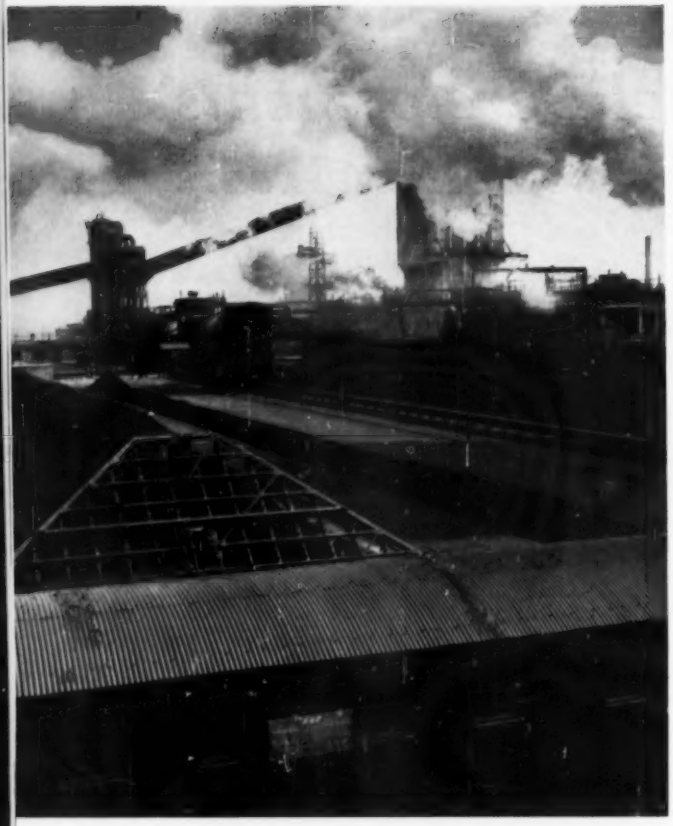
The pattern of use over these years shows some very stable features – particularly the production and use of hard coke for blast furnaces and cupolas, which has continuously increased for much of the postwar period in many industrial countries. Any substitute has yet to challenge this situation. However, other patterns show substantial changes; a well-marked example is the extensive adoption of liquid fuel for openhearth furnaces in the British steel industry where producer and other coal gases were formerly almost universally used. Efficient electrical heating of large furnaces has also arrived and bids fair to extend well into the field hitherto held by the openhearth furnace for tonnage steelmaking. These are some of the trends which guide current changes in fuel usage.

Most of this mainly concerns ferrous metals, for the factors which govern the usage of metallurgical fuel have a more marked impact in iron and steel than in nonferrous metallurgy. However, there are some parallels, and some developments have been more extensively explored outside the steel industry.

Furnace and Foundry Coke

The great increases in demand for hard coke as fuel in shaft furnaces (cupolas included) has been met almost entirely by expansion of coke oven capacity, with a proportional increase of demand for coking coal. These increases, experienced and foreseen, have led to real concern over the adequacy of future reserves. So far there have not been serious shortages, though there has been little increase in the actual supply of the highest grade coking coals in Europe. What is more, the cost of getting these coals is generally higher than for the less scarce noncoking types – often simply because those deposits of coking coals which were more readily

* Lately of the Coal Research Establishment, Stoke Orchard, Cheltenham, England; Head of Carbonization Research. The author would like to record his appreciation to colleagues in the fuel, iron and steel, and other industries in the United Kingdom for their assistance in assembly of technical material. The descriptions given, and any views expressed, are the author's own, and are not necessarily endorsed officially by the industries concerned.



Bedding and Reclaiming Plant for Blending Coking Coal. (Courtesy Fraser & Chalmers Engineering Works of General Electric Co. Ltd. of England)

available and cheaply won have long since been exhausted.

Accordingly, a good deal of development, as well as basic research, has extended the range of coals suitable for carbonizing in existing coke ovens and in ovens of new design.

Blending at Coke Ovens

Practically all coke oven plants erected in the last 20 to 25 years have been equipped for blending several coals into the feed, usually by storage bins and feed tables. Blending is almost universal in the steel industry in Britain, as in the United States, most ovens being located at the furnace sites.

A few most modern installations, including one in the United Kingdom shown in the above view, possess bedding and reclaiming equipment. The quality of coke is now generally maintained at a level which meets the requirements of their own blast furnaces, largely because usual practice is to use about 15% of good high-rank coking coal in a blend of coals of only moderate coking quality.

It has been well established in practice, and moreover has been determined systematically by large-scale experiment, that such relatively small additions of high-grade coal give more than a proportionate increase in coke strength. Basic research, on the test-oven scale, has confirmed and rationalized such practice. It has been shown that the relationships between blend composition, and coke quality and plasticity (as coal temperature rises during the coking process) are similarly disproportionate.

Geography has some influence in this situation. Since coal supplied to steelworks, which may be located near ocean ports or on ore fields, probably has to be moved long distances and possibly double-handled (no matter where the coal comes from), small additions of good blending coals may thus be economic. In contrast is the position of a coking plant at pithead, where the cost of outside coal supply and its freight charges could not be faced.

This widespread practice of blending has certainly been essential to the continued operation of coke ovens and may already have had a significant influence on the reserves of coking coal. The research and development work has also proved that substantial amounts of low-rank noncoking coals can be added to blends without seriously weakening the resulting furnace coke. When this finding is thoroughly exploited, it will result in a much more favorable situation in coal reserves than if the future depended only on the coals of the comparatively high rank now mainly used for coking.

Much work has already been done in France on a large experimental scale on the use of semi-coke made from the high-volatile components of the present blends, and the selective preparation of each petrographic constituent of the coals. There is also the plan used by the western plants of the United States to make special provision for transportation and handling of cokes made from lower rank coals so that breakage is avoided before charging to the furnaces.

Among the more radical suggestions which depart from present practice is the inclusion of fine iron ore in the coal blend. By this means, some reduction is effected during carbonization. When coal with well-marked plastic properties is used, the coke remains coherent and is consolidated by the metallic inclusion. In a related

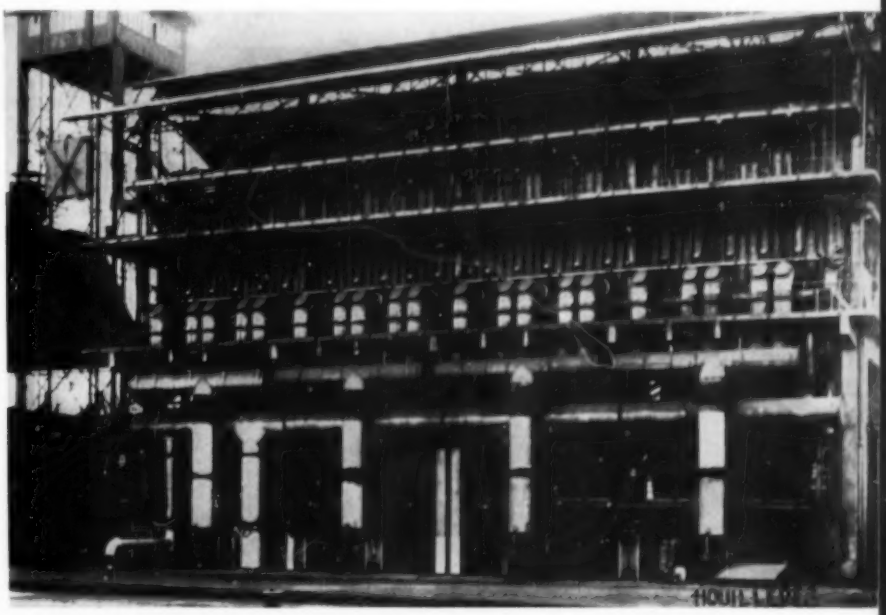
process, coal of inferior coking quality can be used, the ore and coal being formed into briquettes for smelting. This work has been mainly associated with the study of low-shaft furnaces; so far the idea is not widely adopted, but it is of interest in making use of both fuel and ore in a fine state of subdivision, a matter likely to be of increasing future importance.

Alternatives to Oven Coke

The mixture of ore and fuel foreshadows what may be an expected trend. It is already apparent that low-rank fines are likely to constitute much of the future coal supplies. While these cannot alone form the charge for coke ovens, it is possible to make aggregates by briquetting, which can then be carbonized under controlled conditions into briquettes or "form-coke". Such proposals are not entirely novel, as there has been a small annual production over the past decade — a grand total on the order of a million or two tons. So far this has been confined to the manufacture of anthracite substitutes for domestic use, and of course represents only a small fraction of the total output of carbonized fuels. Moreover, it has been based almost entirely on high-rank coals for reasons specific to individual plant locations, and because of unsolved problems in the use of "general purpose" low-rank coals. The photograph below of a French plant for carbonization of briquettes in vertical retorts is an example of the equipment in operation on the Continent.

Although there are exceptions, one cannot usually be sure that coke can be made successfully from such coals without pretreatment before briquetting and carbonizing. In one example of such a process, the coal was first partially carbonized in a vertical retort, then crushed, briquetted and finally carbonized at high temperature to a hard low-volatile product. Questions about the economics of such a multistage process have been raised, and other investigations have been concerned with more productive plants, fully utilized with shorter process times.

For example, in one process so far taken to the semitechnical scale, fine coal cleaned by froth flotation has been devolatilized in a fluidized bed. Such a reactor could, in principle, be of the large through-put now common in petroleum refineries and similar chemical plants. The product, with 15% remaining volatiles (reduced from the 37% in the coal) is fed hot to briquetting rolls, mixed with byproduct tar, and the briquettes carbonized at a high rate, either by heat transfer from a solid medium in a fluidized bed, or by highly turbulent gas. The first devolatilization prevents distortion of the briquettes by reducing the mass to be lost during final carbonizing. It has been shown that conditions at each stage should be individually adjusted if the aim is to produce coke (on the one hand) or smokeless fuel (on the other). In particular, a higher precarbonizing temperature is required for the dense final product needed for foundry coke.



Static Vertical Retorts for Carbonization of Egg-Like Briquette of Medium-Volatile Coal. (Courtesy Houilleres du Bassin d'Aquitaine, France)

The matters outlined above relate mainly to fuels for existing uses in high-shaft blast furnaces or in cupolas; their continued replacement and extension in numbers lead to a dominant demand for these fuels. Simultaneously, important developments have occurred on radically different furnaces, particularly the low-shaft blast furnaces* and electric furnaces. These can operate with a wide range of fuels, including raw coal in small sizes. It would seem unlikely that any supply limitation would be met compared with other furnaces requiring specific fuels. There are also frequently published proposals for direct reduction of ore by gaseous fuel. Such schemes have been operated in Europe on a restricted scale, and a 2000-ton daily operation is in the study stage in the United States.

There are also important ancillary developments which greatly influence the usage of fuel – especially the trend toward higher proportions of sinter in blast furnace burdens, which effectively transfers some of the demand from furnace coke to coke breeze for the sinter plant. When all this is said, however, hard coke – and fuel made as nearly like it as possible – will probably remain the mainstay.

Steelmaking Fuels

It is clear that two main avenues have been followed to meet the stringent and specialized demands for blast furnaces during those years of the postwar decade when production was rising. These are *(a)* expansion of present production and research on conventional coke, and *(b)* development of alternatives. Turning to steelmaking fuels, we find a contrasting position in that there has been a great change, especially in British practice, from a prewar pattern where the openhearth furnaces depended on producer gas made from raw coal. The transition has been to oil firing, a practice established earlier in America. Consumption of oil in openhearth furnaces is one of the largest single uses of heavy fuel oil in the United Kingdom; it now amounts to about 20% of the heavy grades of petroleum.

This change from producer gas is a radical departure, and is important on several counts. Conversion to liquid firing has given *(a)* better rates of production, *(b)* higher thermal efficiency and *(c)* better adaptability of fuel and firing equipment to automatic control. In the British steel industry these advantages *followed* rather than led to liquid fuel conversion; oil was first introduced in times when the supply of solid fuel was scarce. Once started, however, exploitation of the technical advantages was rapid; and since the high proportion of British steel is made in openhearth furnaces, the change was of great practical value.

Of the extensive technical investigations on the use of liquid fuel, the more important and

*See *Metal Progress*, April 1950 and January 1955.

90-Ton Arc Furnace. (Courtesy Birlec, Ltd., Birmingham, England)

systematic are the International Flame Radiation research projects. In these programs, experimental furnaces are specifically designed so the conditions are such that measurements can be readily applicable to actual combustion in openhearth flames. The expanding use of automatic combustion control is likewise important – the openhearth furnace was the first and most important steelworks unit to be so equipped. Since 1946, roof temperature and furnace pressure have given the basic signals for controlling fuel and air flow; actual regulation with liquid fuel can be much more readily carried out than with solid fuel. However, automatic controls have been devised for gas producers, and have gained some adherents, but there have been more problems to overcome.

Electric Heat

Another development which also applies well-established operating principles is the increasing production of common steels in large electric furnaces, of comparable capacity with stationary openhearths (though not yet the equivalent of large tilting furnaces). Prior to 1939, electric steelmaking in Britain and on the Continent was practically confined to the special steels made a few tons at a time, for which metallurgical benefits offset the then relatively high cost of electrical energy. The limitations of electricity – despite its process advantages and high "point of use" efficiency – were essentially economic, but uninterrupted increase in the efficiency of the generating plants and the distribution systems has now changed the picture. The competitive position of electricity in wider and wider fields is greatly improved. A study reported to A.I.M.E.'s Openhearth Committee in 1953 demonstrated that – for a significant range of conditions – steel can be produced in large tonnages more economically by electric melting than in the openhearth. Such a conclusion really rests on the comparison of efficiency of two routes: *(a)* fuel to electrical heat energy versus *(b)* fuel to flame to metal directly. While the openhearth is among the most effective of industrial furnaces for rapid heat transfer at high temperature, a modern turboalternator in a central station is now likely to show an even higher thermal efficiency. Moreover, boiler fuel can be much poorer in quality than that for direct use in the openhearth, or even in a gas producer, and this will be reflected in lower price, particularly when low sulphur has to be specified for the openhearth fuel. This transition into electric furnaces can now be regarded as just established; the illustration on p. 114 represents a typical furnace now replacing fixed openhearth units in melting shops in the United Kingdom.

A Look Into the Future

The three main lines of progress outlined above include many important individual advances, and relate to the largest present uses of metallurgical fuels. Not everything is included, of course, and it may even be likely that the brief references to items such as sintering and direct reduction run the risk of underestimating their importance. Moreover, further departures in the field of solid fuels, such as the intensive study of processes for using such material as brown coal, must not be overlooked. On the whole, however, such advances are within the fields already mentioned.

It is perhaps appropriate to close on two items based on substantial technical possibilities, which may achieve great importance in their own way and time, and further influence the future of metallurgical fuels. These are the exploitation of nuclear energy as a heat source for electrical generation, which has just been appearing in Great Britain as a practical achievement at the close of the postwar decade. There is no need to elaborate in a general way on this – the over-all potential is obvious. However, the extra degree of freedom given to the location of metallurgical plants might be emphasized; it might be one of the main lines along which nuclear energy is exploited as energy.

The other possibility is that of direct reduction in a flame of small controlled volume and high intensity. This was mentioned all to briefly by Sir Charles Goodeve in his presidential address to the British Assoc. for the Advancement of Science, Aug. 30, 1956.* Much reservation has been expressed over the prospects for this "Cyclosteel" process, as for many other bold innovations of the past, but if it is successful, the whole integration of fuel, as well as the whole capital investment picture of future steelworks, would be radically changed.

For the time being, however, the sheer bulk of investment in present plants will doubtless tend to stabilize the situation. For such a period of slow changes, developments and applications, supported with further research if needed, will permit us to consolidate the supply and use of essential metallurgical fuels which rank high in importance among the raw materials of industry as a whole.

*See digest on p. 152 of this issue.

Progress in German Steelmaking

*By H. W. BALSTER**

Plants are being renovated and modernized from blast furnace to rolling mill. West African ore will supplement German reserves, blast furnaces will be using high pressures and oxygen, openhearth, electric and converter melting methods are constantly improved, and rolling mills are being mechanized. Economies all along the line continue to keep Germany high in steelmaking. (D-general)

ACCORDING to the plans of the European Coal and Steel Community, Germany will produce 43,000,000 tons of crude steel by 1970. However, Germany can only supply 20% of its requirements from mines inside its boundaries. Iron ore mining in Western Germany has already reached maximum, but output is nowhere near enough to satisfy German needs.

Just as America has thoroughly studied its future ore demands for years (and solved her problem with taconite pellets), Germany is turning its attention to the 8,840,000,000 tons of Conakry ores in the bogland of French Territorial Africa. These ores, which are low in phosphorus and contain about 1.5% chromium and aluminum gangue, have about 50% iron. This deposit, mined by open-cut methods, contains double the iron quantity of all Scandinavian mines. Tests by the Hoesch-Westfalenhütte showed that a 35% Conakry ore burden can be economically used for large blast furnaces. With a 100% Conakry burden, the aluminate slag (according to Seailles patents) is leached by water, and a very high-grade alumina for aluminum production is produced. Cement is made from the residues. Pure oxygen removes chromium from the hot metal. In this process, two water cooled copper nozzles are immersed 12 to 16 in. into the liquid metal. The nozzles are angled so that one is blowing in an opposite direction to the other. Primary purification of a 40-ton ladle will last 50 to 60 min. and reduce chromium to 0.09 to 0.12%. It seems that the ore bottleneck will soon be partly cleared.

*Director of Development and Research, Rheinische Stahlwerke, Düsseldorf, Germany.

Energy Savings by Hot Cooling

During the last seven years, a 15% reduction of total heat consumption was reached by doubling production rate, changing materials, introducing technical novelties, changing fuel consumption, and thermal measures.

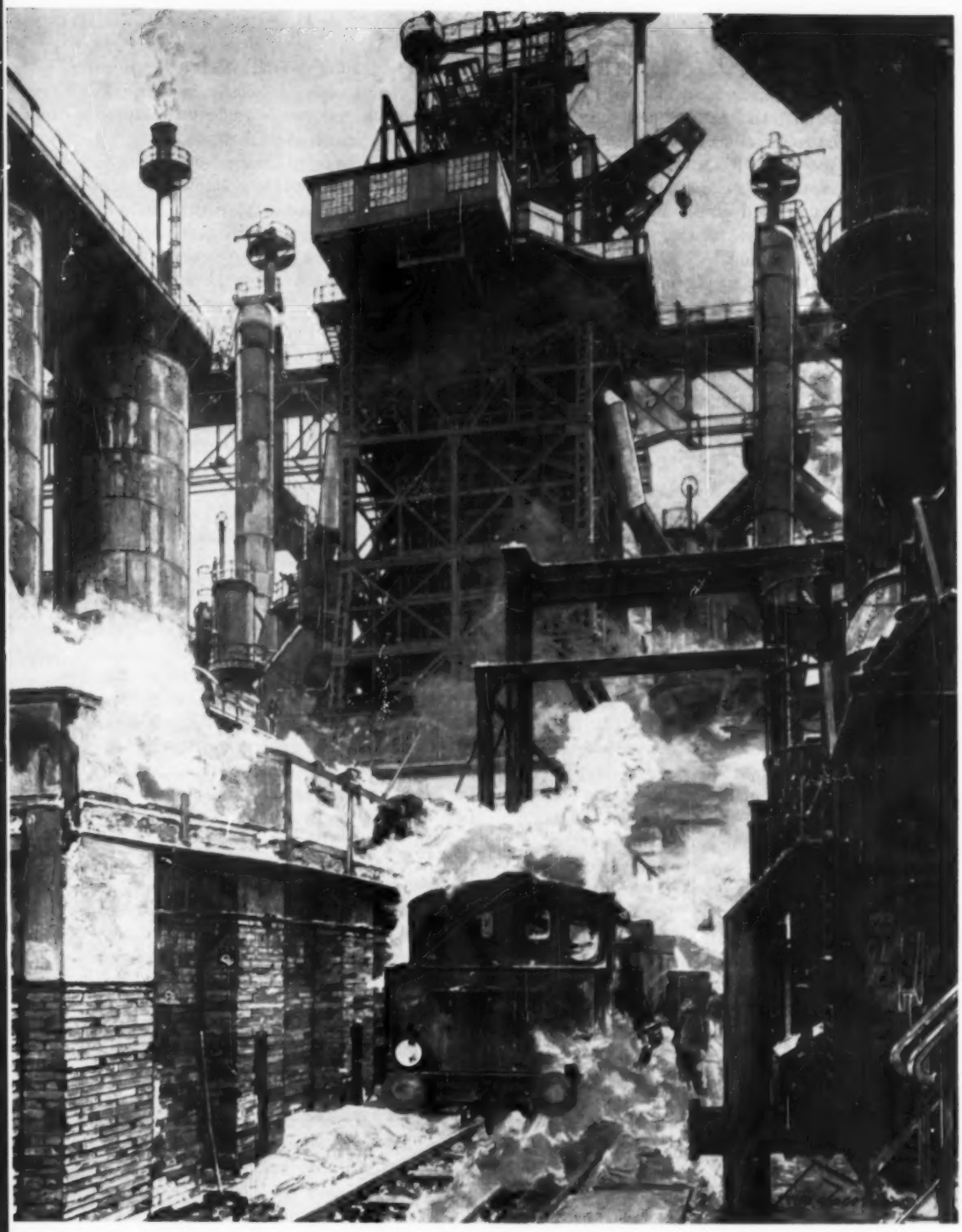
Hot cooling may play an important part in water and heat economies. The technique is to cool, through water evaporation, vital operating elements exposed to considerable heat.

In a steel plant put into operation in 1956, the production of 168-ton steel heats (at 20.7 ton per hr.) required 1,090,000 kg-cal. per ingot ton during the first year. With waste heat boilers and door frame hot cooling, 500,000 kg-cal. could be recovered. Furthermore, hot cooled door frames caused less trouble than water cooled frames.

In the re-erected Hüttenwerk Salzgitter, three basic hot blast cupolas were built. Their shells were provided with a hot cooling system consisting of water boiler tubes. After some difficulties, the system functioned satisfactorily and 40% of the input energy will be recovered.

Blast Furnace Output Increased

We will need an additional 1,000,000 tons of pig iron per year in Germany. As in the United States, the cost of new blast furnace facilities forces investigation of all possibilities



German Blast Furnaces Are Enclosed in Steel Scaffolding Supporting the Top Works. From a mural by Fritz Jacobsen

for increasing existing capacity. In some plants high pressures (4.3 to 8.5 psi.) are applied beyond the stock line. This method reduces the specific gas volume, decreases flow resistances in the stock column, and results in higher efficiency. The capacity of each furnace rose to values from 12 to 20%. Flue dust was reduced slightly but coke consumption did not alter. The use of crushed and sized ore raised iron production of one blast furnace by 6% and reduced coke consumption by 220 lb. (and the dust by 144 lb.) per ton of pig iron.

In the Rhine-Ruhr district, a number of sintering plants partly equipped with special dust removal equipment are being built; they will enable an increase of the sinter used in the blast furnace. Ultra-acid slagging practices and oxygen-enriched blasts are also being tested.

Steelmaking

The classic processes for producing steel in basic bessemer converters and openhearth furnaces are still important. Constant experimentation continues to improve the methods. For example, beside the usual process of applying oxygen and steam in the bottom-blown converter blast, Phoenix-Rheinrohr A.G. developed a new method which they call the PL-Process. It has three stages: In the first stage, lasting approximately 6 min., the carbon content is reduced to about 0.3%. The converter is then tilted to become the equivalent of a hearth-type furnace. A water cooled lance injects oxygen for another 6 min. to slag off most of the phosphorus. The converter is again tilted up and blown. The phosphorus, sulphur, oxygen and nitrogen in this steel are approximately the same as that in openhearth or oxygen converter steel. Since ores rich in phosphorus are available in Europe and there is a great demand for basic bessemer steel, this plant has decided to erect a classic basic bessemer converter plant with 50-ton converters and larger units to use this process.

In the openhearth division, the hot blast cupola furnace can increase steel production considerably by providing a very reactive hot cupola iron as a burden. Due to this, Hüttenwerk Salzgitter was able to augment its capacity by about 39%; the hourly production of the 165-ton tilting furnaces stepped up from 21.2 to 29.2 tons. The Gussstahlwerk Witten reported that charging hot blast cupola iron into their openhearths increased capacity by 20% and lowered heat costs by 21%. Liquid cupola iron composed 40% of the charge. Its use in both plants was justified by the capacity increase and cost reduction.

The use of oxygen for producing basic openhearth steel is gaining ground, since it has been ascertained that melting efficiency is increased while heat consumption is reduced. Lance-introduced oxygen considerably speeds melting as well.

In contrast to American practice, German works maneuver charging boxes with cranes. A high charging capacity (and very short charging periods) is obtained by cranes working two by two on a single furnace. Several steel plants, newly built during the last years or modernized, follow this arrangement.

The L-D process is slowly coming through. The Bochumer Verein plant is operating, but reports have not yet been published. Reports on Gussstahlwerk Witten's 33-ton spherical converter are available. The latter is charged with liquid metal from a hot blast cupola furnace, and its economy depends very much on the price of oxygen. By means of hot waste gases, steam is produced in a waste heat boiler designed according to the La-Mont system. The calculated efficiency amounts to 86%. Regarding the cost, it can be said that duplexing carried through an electric arc furnace reduced quite considerably the consumption of current and electrodes, and this essentially increased the capacity. So far, steel made directly from hot blast cupola iron in an L-D converter is still more costly than openhearth steel.

A series of service tests made in Austria and by the French metallurgical plant, Société des Aciéries de Pompey, confirmed that the L-D process can also be applied for hot metals with a higher phosphorus content. In 33-ton vessels, iron containing up to 1.5% phosphorus can be worked into steel. As soon as the phosphorus content exceeds 0.5%, it will be necessary to work with two slags. In the first stage, phosphorus is reduced to about 0.5% or less, while the carbon drops to 1.5 or 2%. Special attention must then be paid to a very early slag formation and a great availability of iron oxide caused by a sudden addition of fine ore; finish blowing is then done exactly as with L-D steel. For economy and for speeding the process, the second slag will be used for the first period of the following melt. The curved part of the L-D converter mouth must be provided with a tap hole. This opening permits the finished steel to run out as quickly as possible.

In Germany the number of large electric arc furnaces has constantly increased. Mostly 90 to

130-ton furnaces have been built; they are operated according to the openhearth (single slag) practice.

Some German steelworks producing high-grade steels have installed induction stirrers on their newly built arc furnaces. Working according to electric motor principles, a movable electromagnetic field compels the liquid steel to flow in the same direction. During the oxidation period the stirring coil has no influence. However, during refining, metallurgical reactions between melt and slag are accelerated while the coil is operating. Alloys are uniformly distributed in the bath, and sulphur content is reduced appreciably. Further advantages, such as the facilitation and improvement of slagging, temperature balance during the melting process, as well as an important shortening of the refining period, can be gained. Steel made in this manner will be especially useful for heavy forgings which, if used for generator shafts and turbine rotors, must have excellent physical properties in all directions.

To existing vacuum degassing methods a new process has been added. Developed by the Henrichhütte of the Ruhrstahl A.G., together with the firm Heraeus of Hanau, the vacuum container, which possesses two protruding pipes, is transported over a ladle with liquid steel. It lowers and the two pipes dip about 10 in. into the liquid steel. The whole system is evacuated by large vacuum pumps and an inert gas is passed into one of the pipes. This gas, usually argon, renders the steel sucked into this pipe physically lighter at this point so that the steel flows into the vacuum container. The inert gas disperses the in-flowing steel, submitting a large surface to vacuum degassing. As soon as all gases are removed, the steel becomes heavier and flows back into the ladle through the other pipe. The treatment can be controlled and lasts approximately 15 to 25 min. for about 110 tons of liquid steel. Considerable quantities of hydrogen and oxygen are removed.

Continuous Casting

This process grows only slowly in importance. Planning for casting large slabs (8 × 59 in.) has been completed and no special technical difficulties should be expected with 70 to 90-ton charges. In Germany two well-known firms design and build such plants; no large plant has been erected so far, evidently because slabbing mills have not yet reached capacity.

In Germany there is also a great interest in smaller plants. The Benteler-Werke in Paderborn is operating a Rossi continuous casting machine for 4¾-in. square billets. Liquid steel made in 16.5-ton arc furnaces is cast and rolled into strips of welded pipe. Continuous cast blanks aid hammer and drop forging operations considerably if axial porosity in the billet is practically eliminated. This aim can be reached by a certain casting speed and a fixed ratio of forging reduction. Indications are that more continuous steel casting plants will be erected in Germany.

Rolling Mills

A definite further development has occurred in German rolling mills. We aim now at building fully continuous rolling mills and large single-purpose plants. Due to progress made in electrotechnics for measurement and control, fully continuous rolling mills fitted with individual drive for each rolling stand have been built.

In 1958 new rolling mills for wire, strip, rounds, billets, medium plates and sheet were put into operation in Germany. Our iron and steel industry also regained connections with the highly developed industry of America.

Transportation

Ever increasing mechanization makes greater and greater demands on transportation. The importance of traffic planning within plants increases steadily. More and more conveyer belts are installed, especially for ore dressing and the transport of coke to the blast furnace.

When the Hüttenwerk Salzgitter was rebuilt after dismantling, traffic was distributed on three levels. Passenger and automobile traffic operates on an elevated road in the form of a concrete bridge. A second bridge serves for rail ore transport and transportation of dressed ores to the blast furnace. All other transport passes through the mill floor. This arrangement makes some desired expansions possible and reduces traffic blocks and accidents because of the small number of road crossings on the same level.

Conclusions

Constantly increasing costs for modernization necessitate the utilization of all newly built plants to the utmost. Therefore, all metallurgical and other processes which answer this purpose have first priority.

In 1958 the recession resulted in a sensible decrease in German integrated steelwork production. One hopes that further rationalization of production will protect the plants from any such crisis in the future.

Metallurgy in the U.S.S.R.

*By J. HERBERT HOLLOMON**

Russian production, abetted by highly respected scientists, threatens to overtake that of the free world. This challenge must be faced with enlightened technical leadership if we are to stay in front. (A-general)

IN A RECENT VISIT to the United States, Academician Bardin, vice-president of the Academy of Sciences of the U.S.S.R., said in essence: "We in the U.S.S.R. have two problems; one is to build our metals industry and the other is to develop our system of transportation. These are the bases for the industrial expansion of our country." The Russians now have entered an industrial era like the one the United States experienced in the last century. Spurred by European investment, the exploitation of our natural resources, accompanied by an expansion of transportation facilities, began about the time of the Civil War. Our West was opened with railroads and waterways. The steel mills of Pittsburgh, Cleveland and Chicago were constructed to exploit rich iron deposits in the Mesabi range. This explosive, expansive growth lasted for 30 to 50 years. It was a period when resources were exploited for the growth of the country.

This same stage was approached only 20 years or so ago in the U.S.S.R. However, little outside capital was available in Russia. Capital had to be created almost wholly from the work of Russians themselves. Millions of forced laborers also helped produce the capital with which to build the steel mills, the roads and the railroads.

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A Unique Situation

Because of the difference in the stage of industrial development, Russian metallurgy differs from that of the United States or from that of any country of Western Europe, for that matter. This difference is reflected in education of metallurgists, research in metallurgy, and types of innovations arising from research. For example, many of the recently built blast furnaces and openhearths represent new capacity; few replace existing plants. Whenever a new metallurgical development is considered, Russians ask only if the process is the most economical and productive. Whether the new process is sufficiently economical to replace existing processes or equipment is not particularly pertinent. And since a greater part of Russian primary metal capacity has been installed in recent years, average production rates might be expected to be higher than those in the United States.

A recent visiting American team reported that because of the need for capital goods "steel is

Fig. 1 – (Left to right) G. V. Kurdjumov and A. M. Samarin With Dr. Karasev. All are active in Russian iron and steel research

king". The largest fraction of technical publications in Russian metallurgical journals is devoted to the properties, heat treatment and reaction kinetics of iron and its alloys, and to the physical chemistry of the steelmaking process. Less emphasis is placed on nonferrous metals, and still less on the specialty alloys which are so important in our technology.

Training Is Specific

Such a rapid expansion in the basic metal industries requires that a large number of highly specialized technicians be trained in a short time. It is as if a quarter of the about 20,000 American metallurgists would have to be produced in five to ten years; this would mean 4000 to 5000 each year. Figure 2 shows the growth of metallurgy graduates in the U.S.S.R. during recent years. In 1958 the number of metallurgists graduated probably did reach 4000. In the same year about 700 metallurgists were trained in the United States.

A highly specialized curriculum produces highly specialized metallurgists in Russia. There are, for example, specialists not only in ferrous and nonferrous metallurgy but in openhearth, blast furnace and cupola metallurgy. Specialized plant experience is also required for all graduates. During the fourth year, each student spends eight weeks or so in a workshop in his particular field. Two months of specialized practice are required in the fifth year. This scheme works well now, but in ten years these "narrow" people are likely to be unsuited for the further development of their metallurgical industry. (In the United States the opposite trend is apparent – metallurgical training is expanding to include not only more science but the behavior common to all materials.)

Status of Steelmaking

Because of the importance of steel to the Russian economy, the U.S.S.R. recently exchanged a large contingent of steelmaking management and technical people with the United States. The American visitors report that the U.S.S.R. has unquestionably concentrated its human resources, money and machines on raw materials, blast furnaces and openhearth furnaces. Russian practices in these areas are equivalent to the best practices anywhere. They began to use vacuum ladle degassing earlier than we did,

and lately have begun to use the "Bochumer Verein" process for casting ingots in vacuum.

Their heavy rolling and forging equipment and their cold mill practice seem much less modern than ours. Russians worry little about highly finished materials or about the quality* of the hot or cold mill products since they need the rough structural materials to build heavy equipment and transportation systems. Refinements are for the future.

The U.S.S.R. plans to produce 70,000,000 tons of steel in 1960 and 125,000,000 in 1967. (This capacity does not include Czechoslovakian, Polish, Hungarian and East German production.) This growth in steel and in other primary metal industries will allow the Russians to sell metal products throughout the world. They will certainly try to use their metal capacity for economic penetration into Asia, Africa and South America. Since their industry is completely controlled by the central Soviet, exploitation and penetration is possible without having to worry about the profit of the metals industry but only about the supremacy of the Soviet state and peoples. If we take no contrary action, the poorer countries who receive this support will depend on it for markets and will ultimately be enmeshed in the Russian political system.

Centralized Research

Central control of industry also leads to large centralized research and development. Under the "Gosplan", the central organization for industrial management, large laboratories (both nonferrous and ferrous) have been established. These, unlike most laboratories here, study technology and science concerning problems that affect the country and its metals industry as a whole, rather than the problems of a particular company or a particular industrial segment. There are also metals research institutes connected with the Academy of Sciences. The largest of these is the Baikov Institute headed by the very-important Bardin. (He is probably the key technical person in metallurgy in Russia.) He is vice-president of the Academy of Sciences, head of the Central Industrial Laboratory of the steel industry, head of the Baikov Institute and of the Academy of Sciences of the Urals. More than any other man he has been responsible for the quality of metallurgical research and the substantial advances in the steel industry.

These large central research institutes, concentrating as they do on basic metallurgical problems, put more effort into metal processing research than we do. They are also better able to tackle problems of broad national consequence that might not be profitable to study in small industrial complexes. As mentioned before, little effort goes into the study of special properties of materials which we regard as so important in advanced applications.

The growth of research in Russia is clearly indicated by the increase in the number of Russian articles abstracted in the ⊕ Review of Metal Literature. In 1951 the number of Russian articles was 189, which was 2.7% of the total abstracts. By 1956, the Russian abstracts

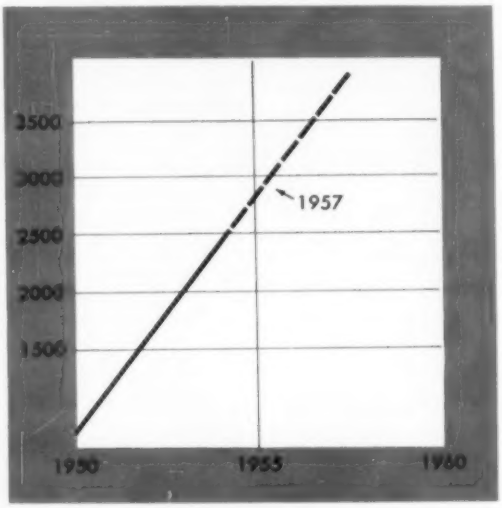


Fig. 2 – Graph Showing Increase in Russian Metallurgical Graduates

numbered 824 or 9.7% of the total. Of course, part of the increase arises from the greater interest and availability of Russian articles but certainly there has been a rapid growth in their metallurgical research as well. The growth is reflected not only in the number of published articles, but also in the rapid increase of the number of metallurgical journals. Some of these are currently being translated by the Board of *Acta Metallurgica*.

Russian research is carried on in a way very similar to the older European systems. Work is closely directed by a senior scientist, usually a professor or a doctor. His control is nearly com-

*For example, they make an oriented type of silicon iron for transformers. Its magnetic quality would not have been accepted in this country, even five or ten years ago. Alloy steels generally are of lower quality than are produced in the United States.

plete; his "school" reflects his scientific viewpoint and his competence. Young American metallurgists have more independence. On the other hand, senior research people of Russia are mostly free from control by industrial or academic management and seem to be freer of the "projectitus" disease infecting the United States. Respect for senior technical people, as well as their influence in society, is apparently greater than here. G. V. Kurdjumov, for example, has a very large group working on problems which are not obviously connected with industrial or military requirements even though he is in an industrial laboratory. Other senior scientists in institutes have similar programs.

In general, the average quality of published research is lower than that of the western world. Further, the poor connection between theoretical work in the physics and chemistry of solids and the more experimental approach of the metallurgist is evident. Russia's concentration of research in large centralized institutes devoted to specialized subjects and disciplines tends to compartmentalize the research somewhat more than does our competitive type of organizations and tends to give great emphasis to certain fields. The Russians themselves consider the United States now to be pre-eminent in the general field of scientific research and in engineering as it is currently practiced.

Development Period Is Minimized

The Russian emphasis on science, engineering and technology has produced capable managers, technically trained and oriented. They are apparently able to translate science and technology into practice more quickly than we. This is not a result of better science and engineering or better people, but rather is due to belief in science and engineering as a means for improvement of industry and as a way to bring prestige and power to their nation. The time required for decision making is apparently shorter, and the concentration of effort after decisions are made seems to be greater in the U.S.S.R. than here. Evidence of this effective execution is their rapid development of the hydrogen bomb and intercontinental ballistic missiles and the short time it took them to develop high-production steelmaking units. This great respect for technical people may be their "secret weapon".

To accomplish this translation of technology to production, the U.S.S.R. gives scientists control of experimental pilot plant and production equipment rather than depending on operating management to demonstrate the feasibility of new ideas. For example, a steel mill at Tula is controlled by the Baikov Institute for Metallurgical Research; Bardin and Samarin can authorize steel production at that plant for experimental rather than for industrial use.

Areas of Emphasis

In the metallurgical industry, the Russians concentrate on some fields, ignore others. As already mentioned, they have concentrated on production of basic materials without a corresponding effort on metal fabrication. Recent news indicates a large concentration on titanium and zirconium metallurgy, and a large effort is certainly beginning in controlled atmosphere melting. Conversely, there has been little activity with tungsten, molybdenum and chromium.

In their basic work, this concentration is also evident. For example, until 1957 there was essentially no Russian research on dislocations. Earlier work by physicists was not followed (nor apparently thought too important) by the metallurgists. On the other hand, there had been a very large effort on the surface behavior of metals and on transformations in steel.

The Future Picture

Continued growth in basic metals production capacity, along with improvement in fabrication facilities, should be expected. Research and development activities having to do with the basic metals, and with special alloys and materials, will expand. The Russians in the last ten years have grown into a modern industrial nation. One can expect them to support research, development and industrial activity leading to further growth, expansion and diversification.

For us to live with this adolescent giant, we must be familiar with his work so that our own effort can be more effective. We can expect more Russian innovations and we must be able to exploit them as they do ours. We must also realize that the growth in the metallurgical industry will give them products to trade with the world's poorer countries. We must learn how to meet this economic threat.

The Russians seem to be able to translate research into practice more quickly than we do. Apparently this comes from a greater confidence in scientists and their contribution to society. Our leadership must become more confident. Metallurgy and metallurgists are of first rank importance in the U.S.S.R.. They must become more important in the United States.

Photograph of Pearlite. Full-sized reproduction of a micrograph taken at 1000 diameters

Short Runs

A New Metallograph

AT THE METAL SHOW in Cleveland last October, Leitz's latest metallograph was exhibited, and attracted a lot of attention. Developed under the direction of Hein Claussen in Wetzlar, Germany, it incorporates many new features, including an extremely bright xenon-filled lamp that enables easy screen viewing in a normally lighted room. Its main advantage is well-illustrated by the picture on p. 125. Reproduced in actual size is a photomicrograph of pearlite taken at 1000 diameters. The specially designed objectives, which range from 3.2 to 160 ×, produce an exceptionally flat and sharp image across a 5 × 7-in. field.

One unusual feature is the series of seven filters that shield the lamp. They are graded in density, and flip into position by the mere push of a button. Thus, light adjustment is made very simple. Viewing of the image by other observers is accomplished with a 15-in. diameter screen at the metallographer's left. A pre-aligned 5 × 7-in. camera (or a 4 × 5 picture-in-a-minute camera, if desired) takes the photograph.

Polishing With the "Ellopol" Apparatus

By PIERRE A. JACQUET
Marine Nationale, Paris, France.

A CONVENIENT portable polishing method, termed "plug electropolishing" by its French inventors, employs a hand-held electrode coupled to a lightweight power supply. The setup is shown in Fig. 1. Watercooled (to avoid overheating), the stainless steel plug head is covered

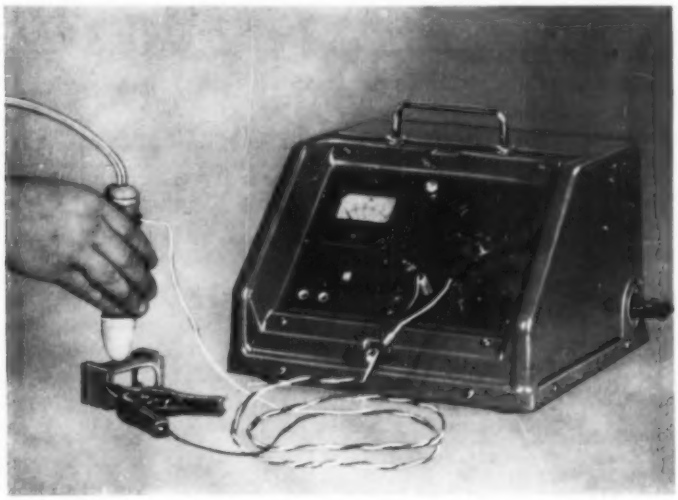


Fig. 1 – "Ellopol" Apparatus for Electrolytic Polishing. The light, portable equipment operates on 120 to 230 v. and can easily be carried wherever necessary

with an absorbent sheath of either fiberglas or synthetic fabric. Its handle is plastic.

Operation of the equipment is quite simple. The plug is wet with the electrolyte and applied to the desired surface for a few seconds at voltages that depend largely on the metal being polished. Average values are: 20 to 35 v., 0.3 to 0.5 amp., and 30 to 60 sec.

Since plug heads of various shapes are also available, a large variety of sizes and shapes can be polished. Sizes range from thin slivers, ½ in. square, up to large machine parts weighing hundreds of pounds. The interchangeable heads enable polishing of concave and convex surfaces; thus small cavities, and inner and outer walls of tubes are easily processed.

Figures 2 to 6 illustrate examples of the metals which can be polished. A tube of phosphor bronze (95 Cu, 4 Sn, 0.3 P) as polished and etched in 35 sec. is shown in Fig. 2. Polishing and etching stainless steel plate took 70 sec. (Fig. 3). Three minutes was needed to polish the forged aluminum alloy (Al, 4 Cu, 2 Ni, 1.5 Mg, 0.5 Si) illustrated by Fig. 4. Zirconium (Fig. 5) also took 3 min. to polish. A special technique was necessary for the micrograph shown in Fig. 6. The figure illustrates a replica taken from a large ship propeller cast from alpha-beta brass. This propeller broke in service; the defect shown was partly responsible for the damage. Many other metals and alloys, including carbon steels, magnesium, beryllium and uranium, can be readily polished by this handy, versatile device.

Fig. 2 – Outer Surface of Phosphor Bronze Tube. Polishing took 30 sec. (20 v.) and etching took 5 sec. at 5 v. Magnification 400 ×

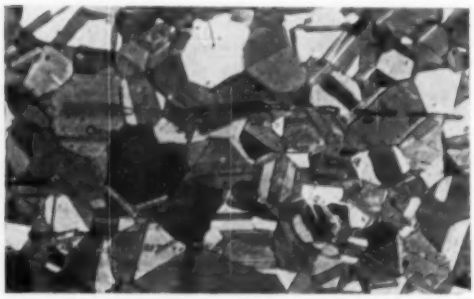


Fig. 3 – Stainless Steel Plate (18 Cr, 8 Ni). Polishing required 60 sec., and etching (in Marble's reagent) lasted 10 sec. Magnification 400 ×

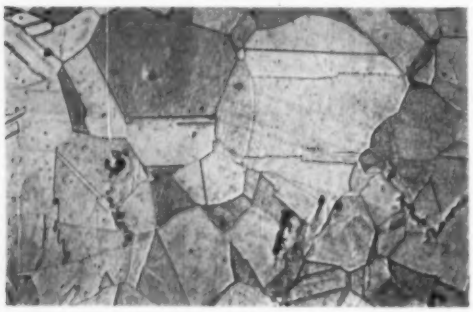


Fig. 4 – Forged Aluminum Alloy. Polishing lasted 3 min.; structure is not etched. Magnification 1000 ×

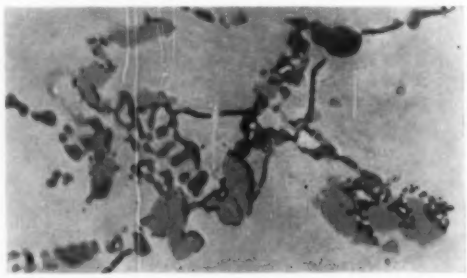
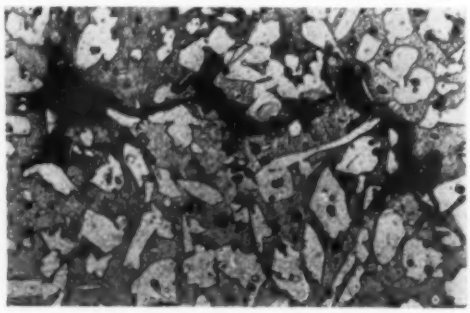


Fig. 5 – Fused Zirconium Polished for 3 Min. Without Etching. This was photographed under polarized light at 750 ×

Fig. 6 – Replica of Defect in Cast Brass Ship Propeller. Polishing took 15 min. and etching took 60 sec. Magnification 160 ×



High-Purity Metals in Commerical Quantities

*By R. A. KING**

The Consolidated Mining and Smelting Co. of Canada Limited, long a producer of lead and zinc of 99.9% purity, has extended its operations to include the production of high-purity antimony, cadmium, silver, bismuth, tin and indium.
(C-general, S11; Pb-a, Zn-a, Cd-a, Ag-a, Bi-a, In-a)

THE HISTORY of metallurgy has shown a continued progression from an art based on empirical methods, often not understood, toward the ideal goals of complete understanding and absolute control. Benjamin F. Shepherd, past-president of A.S.M., has neatly put it in a recent address: "We are moving from practicing an art to utilizing a science." Intrinsic in this advance has been the establishment of increasingly high standards of purity and performance. Each improvement in purity has enabled users to make new applications of metals and these applications have, in turn, demanded higher degrees of purity to ensure satisfactory performance. In the course of this natural development, commercial grades of common metals such as lead, silver, copper and zinc have been produced for many years in large tonnages in purities exceeding 99.99% – that is to say, with a total impurity content amounting to 100 ppm. or less. The influence of small quantities of oxygen on the electrical conductivity of copper, and of lead and cadmium on the stability of zinc alloy die castings in corrosive atmospheres are typical and well-known examples of the need for such purity for satisfactory everyday use. They also illustrate the deleterious effects of specific impurities in metals when they are applied to certain uses.

To achieve this degree of purity, these common metals are refined either by fire refining, electrolysis or by fractional distillation, the choice depending upon the specific metal and the im-

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purities present. Electrolysis and fractional distillation are comparatively recent developments, but the refining of metals in the molten state has been used since earliest times. Modern fire refining techniques, however, bear little resemblance to the original crude operations, and give products of much higher purities. For example, gold and silver can be produced at purities exceeding 99.99% by fire refining, providing more noble metals are not present as impurities. Lead can also be produced at a comparable purity by fire refining, or by the Betts electrolytic refining process. If bismuth is present in the lead bullion, the Betts electrolytic process has the advantage of removing this impurity without the additional processing required with the more commonly used fire refining processes. Copper with a purity of 99.99% is normally produced by electrolytic refining of crude copper, while zinc of this purity is made either by the electrolytic process or by redistillation of crude zinc produced by one of the pyrometallurgical processes.

In recent years, commercial grades of these four metals have been offered with total impurities approaching 10 ppm. and high-purity grades approaching 1 ppm. Further, high-purity grades of germanium and silicon are being sold with significant amounts of other elements measured in parts per billion.

To most of us, a total impurity content of 1 ppm. is infinitesimal (it would amount to 3 oz. of nitrogen, say, in a 100-ton ingot of steel), but to the solid-state physicist, such a metal is extremely impure. As J. C. Chaston has expressed it in his article "Metals of High Purity" in *Metal Progress* for January 1956, in 1 cc. of a metal of this purity, as many as 10^{16} atoms of impurities would be distributed among the 10^{22} present. From this point of view, we are still a long way from *absolute* purity.

The present interest in ultra-high-purity metals has arisen in the semiconductor field, and the principal outlets are to the electrical and electronics industries for such devices as rectifiers and transistors whose performance depends on the electrical characteristics of materials having precisely controlled compositions. For example, the functioning of a germanium transistor depends on changes in the properties of germanium caused by the addition of a carefully controlled amount of an impurity such as indium.

In addition to the electrical properties, the mechanical, chemical and other characteristics of a metal are also influenced by its purity. The effect of impurities is also related to the specific impurity present, its quantity and mode of occurrence, and to the service performed by the metal. The effects of one impurity may be modified by the presence of others and by the physical treatment received by the metal, both of which can influence the mode of occurrence of the impurity in the host metal and, consequently, its structure.

The structural purity of a metal also exerts an important influence on its characteristics. Using special techniques that virtually eliminate imperfections, crystal whiskers of metals have recently been made with tensile strengths over 100 times those of ordinary crystals of the same metals.

Production of High-Purity Metals

In the production of metals of extremely high purity, two different routes have been explored. Some firms prepare very pure compounds of the metal by chemical procedures and reduce these compounds under carefully controlled conditions. The other approach involves the purification of commercial grades of metal.

It is natural that the Consolidated Mining and Smelting Co. of Canada ("Cominco"), with its wide experience in the production of commercially refined metals, should adopt the second method for attaining high purity. Techniques employed have included electrolysis, zone melting, and vacuum distillation, as well as the chemical treatment of metals.

Zone melting has received considerable publicity since its adoption as the standard process for the production of the germanium manufactured into transistors. Metal with total metallic impurities in the order of a few parts per billion can be produced using this technique. However, zone melting will not remove all the metallic impurities from any metal. In the production of high-purity zinc, for example, zone melting will remove heavy metals such as lead, bismuth and cadmium, but not very much of the iron or copper. Thus, unless the starting metal is low enough in the two latter impurities to meet final specifications, the zone melting operation must be preceded by another procedure, such as vacuum distillation or electrolysis suitable to control the iron and copper content of the high-purity zinc.

In producing high-purity metals, we therefore use the process or combination of processes found to be most advantageous for each one. A tentative standard of 1 ppm. or less total impurity content – based on spectrographic, chemi-

Table I – Analyses of the High-Purity Metals in Ppm. *(a)*

Impurity	Lead	Cadmium	Silver	Zinc	Indium	Tin
Copper	0.1/0.2	0.1/0.2	0.1/0.2	0.1/0.2	1	—
Silver	0.1/0.2	0.1/0.2	—	—	—	—
Antimony	0.2	—	—	—	—	—
Lead	—	0.1/0.2	0.1/0.2	1 *(b)*	2	1
Tellurium	—	0.1/0.2	—	—	1	—
Bismuth	—	—	0.1/0.2	—	—	—
Cadmium	—	—	—	1 *(b)*	1	—
Iron	—	—	1 *(c)*	1 *(c)*	—	—
Tin	—	—	—	—	2	—

(a) HP Grade bismuth is also made; no impurities detected.
(b) 1 ppm. or less.
(c) Presence detected; 1 ppm. is limit of determination.

cal and other methods of analysis – has been adopted for current production. Development work is continuing, however, in an attempt to increase further the purity of these metals.

Refining Lead

To illustrate the processing involved in the production of a high-purity metal, the sequence of operations employed for high-purity lead will be outlined.

Most of the lead and zinc made at Trail is derived from the company's Sullivan Mine at Kimberly, a massive sulphide replacement deposit containing chiefly lead, zinc and iron sulphides. After preliminary crushing of the ore, much of the gangue is rejected in sink-float equipment. The remainder is ground and separated by differential flotation into a lead concentrate, a zinc concentrate and a tailing containing iron sulphide. The lead and zinc concentrates are then shipped by rail to the reduction plants at Trail.

Here at the smelter, the Sullivan lead concentrate is treated along with custom ores and concentrates, zinc plant residues and other lead-bearing byproducts. Lime rock and silica fluxes are added, and the mixture is sintered on Dwight-Lloyd machines. This sinter is reduced with coke in blast furnaces; the molten lead is tapped off periodically, drossed to remove impurities and cast into anodes for refining by the Betts electrolytic process.

At Trail the Betts process cathodes, after melting, drossing and treatment with caustic soda, yield refined lead with a purity approaching 99.999%. High-purity lead of 99.9999% is the next step after a second carefully controlled electrolysis. For special purposes, this re-refined lead is zone refined for added purity.

Analysis and Control – The analysis of high-purity metals has posed problems at least as formidable as those encountered in their production. Further improvements, in fact, are still being retarded by low precision of the analytical methods.

Emission spectroscopy* has been perfected to the point where it is virtually the standard method of determining metallic impurities in metals. For most of these elements, standard techniques give results with a sensitivity of 1 ppm., which is adequate for commercial grades of metals where the individual impurities may range from 1 to 20 ppm. or higher, but it is entirely inadequate for high-purity metals where the *total* impurity content may be only 1 ppm. For the high-purity grades of the common metals now being produced, analytical methods are needed giving precise results down to 0.1 ppm., and undoubtedly a still higher degree of precision will be required in the near future.

Special techniques have been developed to increase the sensitivity of the spectrographic methods, but the precision of the results is dependent on having suitable standards which are not now available. This is a matter which is currently under investigation. Work is also in progress on the improvement of polarographic and other techniques for determining traces of metallic impurities, and the use of square wave polarography* has resulted in much higher sensitivity. The development of improved chemical procedures for more precise determination of both metallic and nonmetallic impurities is continuing as a phase of these analytical studies.

*As used in quantitative analysis, emission spectroscopy involves excitation of the metal sample (commonly by an electric arc), dispersion of the emitted radiations with a prism or diffraction grating and measurement of the intensity of strong spectral lines of the metallic impurities.

Neutron activation analysis involves irradiation of the sample under study and examination of the induced radio-isotopes. When several elements in a sample are activated, chemical separations are made prior to study of the radioactivity.

In the square wave polarograph, a square wave alternating current is superimposed on the slowly changing direct current used in the conventional polarograph. This gives a current-voltage curve that differs from the normal curve (actually a derivative of the normal curve) and has increased sensitivity over the conventional polarograph.

Table II – Approximate Weights and Standard Shapes, "Tadanac" Brand

	Lead	Cadmium	Silver	Bismuth	Zinc	Indium *(e)*	Tin
Standard bar *(f)*	4 lb.	3 lb.	25 oz. *(d, g)*	3.5 lb.	2.5 lb.	100 oz. *(d, i)*	2.5 lb.
Cast rods *(h)*	12 oz.	9 oz.	10 oz. *(d)*	10 oz.	7.5 oz.	N	7.5 oz.
Rolled sheet *(a)*	S*	S	N*	N	S	S	S
Shot (0.125 in.)	S	S	S	S	S	S	S
Powder *(b)*	S	S	N	N	N	S	N

*S = Supplied in this form; N = Not supplied.
(a) 12 × 4 in. down to 15 mils thick.
(b) Down to −325 mesh Tyler.
(c) Avoirdupois.
(d) Troy.
(e) Indium is supplied in sheet down to 2 mils thick, wire down to 10 mils diameter, ribbon, powder, disks and spherical and washer pellets.
(f) 10 × 1 × 1 in.
(g) 4 × 1 × 1 in.
(h) 0.5 in. round, 9 in. long.
(i) 9 × 1.25 × 2.75 in.

As well as these familiar analytical techniques, a number of physical methods are available for the evaluation of high-purity metals. Neutron activation* and radioactive tracer methods as well as precise determination of resistivity and melting point have been used.

In semiconductors, certain impurities are significant at concentrations below the limits of the common methods of analysis. The level of significant impurities can be estimated from the Hall coefficient and resistivity values.

Commercial Production at Trail

Typical impurity analyses of the high-purity metals ("Tadanac" brand) produced by Cominco are given in Table I. The lower figures in the quoted ranges are estimates based on present analytical techniques and available standards. No impurities other than those listed are detectable by techniques in current use. "Special Research Grade" of antimony and indium meet the requirements for intermetallic semiconductors, with all significant impurities less than 0.1 ppm.

Standard shapes of high-purity lead, cadmium, silver, bismuth, zinc, indium and tin supplied by Cominco are shown in Table II. Other shapes can be supplied on request.

The special research grades of indium and antimony were developed particularly for production of intermetallic compounds for semiconductor applications. After refining, this grade of indium is treated to reduce its oxygen content, then cast and sealed in vacuum in fused quartz ampoules to prevent contamination. The special research grade of antimony is supplied as sections of zone refined bars, sealed in polyethylene sheet.

Cominco also produces indium antimonide for semiconductors, made from the special research grades of indium and antimony. It is supplied as sections of zone refined bars. In addition the company makes a wide range of high-purity alloys on a custom basis, supplying these in sheet and other forms as required.

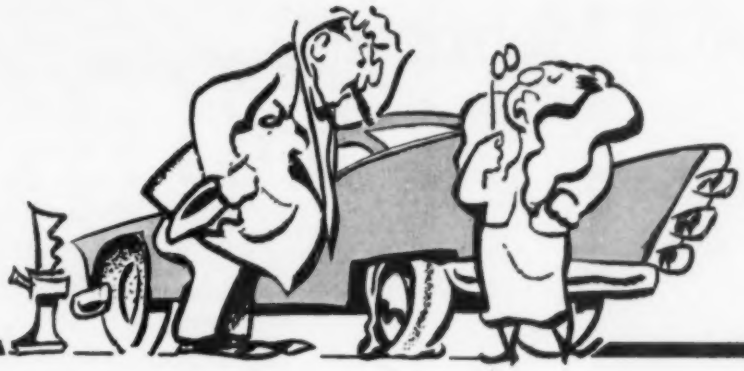
*See footnote on p. 129.

Future Possibilities

Our company is actively interested in the potentialities of high-purity metals. Over 40 years of experience with the electrolytic zinc process has clearly demonstrated the significance of trace impurities in the electrolyte. Effects of impurities may be either harmful or beneficial, depending on the specific impurity and the quantity present. More recent work on the use of zinc in die casting alloys and galvanic anodes, as well as preliminary studies on the properties of high-purity zinc and experience in the production and use of other high-purity metals, have confirmed the importance of purity and control of alloying components.

Indeed, from a practical point of view, *control* of purity appears more important than *high* purity, since the effects of specific impurities are distinctive and the level of each impurity must be considered in terms of the actual application of the metal. The tolerance level of certain impurities varies with the intended use, in some instances being highly critical and in others relatively insignificant.

Another consideration is this: The true properties of a metal cannot be determined until that metal is available in a very high state of purity, perhaps even absolute. It follows that our knowledge of metals will continue to grow as they become available in higher degrees of purity. This increased knowledge will inevitably lead to new applications based on the specific properties of these really pure metals and their alloys.



CHANGE AJAX SALT BATH SUBMERGED ELECTRODES

. . . almost as fast as you'd change a tire!

✓ in about an hour per pair ✓ often while the salt remains molten

✓ without tearing down either furnace or pot

1 A closely fitted but readily removable tile block on top of the furnace seals the new Ajax removable submerged electrodes from air. Electrodes are exposed for easy replacement just by lifting the tile. No skilled labor is needed.

2 Electrodes enter furnace from the top and slant into the bath. There are no furnace openings whatever below the salt line. And there is no need to tear down any part of furnace or pot in changing electrodes!

3 Lift old electrodes out from the top . . . make replacements in about an hour per pair. In many cases, the job can be done while the salt bath remains molten, without even shutting the furnace down.

AJAX

HULTGREN

SALT BATH FURNACES

Internally heated-Electric and gas-fired types.

AJAX ELECTRIC COMPANY

910 Frankford Ave.

Philadelphia 23, Pa.

No more lost production time when salt bath electrode changes are necessary! This revolutionary Ajax design development reduces the job to a matter of minutes . . . and reduces maintenance costs accordingly. Moreover, pot life is vastly increased because the pot is no longer torn down in the electrode changing process. Equally important, although Ajax Removable Submerged Electrodes are made of non-critical materials, their life materially exceeds that of nickel alloy electrodes of conventional design.

Write for Ajax Bulletin 810

Associates: Ajax Engineering Corp., Ajax Electrothermic Corp.

AJAX HAS THE ANSWERS TO SALT BATH HEAT TREATING PROBLEMS!

Personal Mention

William A. Darrah

The merger of Continental Industrial Engineers, Inc., with Lindberg Industrial Corp. in Chicago has resulted in a new job for WILLIAM A. DARRAH – a post as vice-president of the newly created Lindberg Continental Div. Continental Industrial Engineers was organized by Mr. Darrah in 1921 and he acted as general manager and president until the merger with Lindberg last August.

He has had a wide and varied career – beginning with his graduation from Worcester (Mass.) Polytechnic Institute with a bachelor of science degree and a degree in electrical engineering. Prior to the formation of Continental, he directed research at the Western Electric Co. in the division now known as the Bell Telephone Laboratories. He also managed the engineering department of Westinghouse Electric and Mfg. Co., and following that was manager of engineering of the Ohio Brass Co. in Mansfield, Ohio. Later he managed the plant operations of the Noble Electric Steel Co.

In addition to nearly 35 years experience in industry, he has been an assistant patent examiner in the U.S. Patent Office and is still a registered patent attorney in this country and Canada.

His contributions to the industrial heating field have been widely recognized – in 1950 he received the Trinks Award for Industrial Heat Pioneering and in 1940 the Industrial Pioneer Award from the National Assoc. of Manufacturers for achievement in science and invention.

Henry A. Tobey was recently promoted to general factory manager of the bearing and rock bit divisions of the Timken Roller Bearing Co., Canton, Ohio. He joined the metallurgical department of the Timken Co. in 1928, rising to factory manager of the Canton and Gambrinus, Ohio, bearing factories in 1954.

J. L. Goheen has been named assistant manager of the Los Angeles office of Climax Molybdenum Co., a division of American Metal Climax Ltd., New York. Mr. Goheen was sales manager for a foundry producing gray and specialty cast irons for the past four years before accepting his new post.

Hans Ernst has been added to the faculty of the University of Cincinnati as Herman Schneider research professor in the college of engineering. For 32 years he was director of research at the Cincinnati Milling Machine Co. and since his retirement in 1957 has served as the company's research consultant.

Eugene A. Nedwick has joined Peterson Steels, Inc., Union, N. J., as manager of the strip steel division in Melrose Park, Ill. Prior to his appointment as division manager, he was assistant Midwest sales manager for Sandvik Steel, Inc.

Edward J. Bishop has been appointed sales engineer at the Chicago branch office for steels sales of the Timken Roller Bearing Co., Canton, Ohio. He joined the company in 1957 and for the past year has been in training at the home office.

E. A. Loria has been appointed product metallurgical engineer in the Crucible Steel Co. of America's customer technical service section in Pittsburgh. A member of Crucible's metallurgical staff since 1954, he was staff metallurgist in the central metallurgical department until his new assignment.

George T. Murray has been promoted to director of the metallurgy section of Materials Research Corp., Yonkers, N. Y. He brings to his post six years of experience with Oak Ridge National Laboratories and Bridgeport Brass Co.

Melvin F. House, Jr., has been appointed plant superintendent of Michigan Seamless Tube Co. Affiliated with the company for two years, he formerly held the position of assistant plant superintendent.

Albert L. Iannucci and **Myron Skrill** have joined Materials Research Corp., Yonkers, N. Y., as project engineers. Mr. Iannucci is a recent graduate in metallurgical engineering from Columbia University while Mr. Skrill was formerly associated with Worthington Corp.

Edwin S. Lawrence, formerly manager of manufacturing engineering for the Schenectady, N. Y., foundries of General Electric Co., has been transferred to the company's Everett, Mass., foundries as manager of manufacturing.

E. D. Barnes has received a new assignment as application engineer for Wall Colmonoy Corp., Detroit, working out of the Houston, Tex., district office. Prior to joining the company, he was welding advisor on automatic and manual welding procedures for the Hughes Tool Co. in Houston.

W. P. Fitz-Randolph, formerly associated with Ipsen Industries, Inc., Rockford, Ill., as district manager of the New England territory, has resigned from this position.

Harold P. Weinburg, a supervisory materials engineer in the engineering research and evaluation department of the U. S. Naval Gun Factory, was recently awarded a Superior Accomplishment Award of $300 by the Navy in recognition of his initiating a review of nonmagnetic material requirements which pointed up an inadequacy in current specifications. He came to the Naval Gun Factory in 1949 after his graduation from Virginia Polytechnic Institute.

George R. Sylvester, president of Sylvester & Co., Cleveland, has been elected president of the reorganized Continental Coatings Corp., Cleveland.

FAHRITE

HEAT AND CORROSION *Alloys*

CASTINGS FOR HIGH TEMPERATURE SERVICE

DESIGNED FOR LONGER SERVICE

Fahrite alloy castings for the heat treating industry give long, economical service. Careful design, metallurgical and foundry control techniques assure sound castings with high tensile strength and high resistance to thermal shock.

Our engineers need only complete details about the casting requirements of your heat treating operation to design and produce Fahrite castings with the correct characteristics to meet your exact operating conditions. A few of the many types of Fahrite castings made by Ohio Steel are:

Rails	Rollers
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Muffles	Chain
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WIRE
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entry wire to accurate size through carbide dies
2 FLATTENS
wire in precision 8" mill with water cooled carbide rolls
3 SIZES AND EDGES
SIZES AND SHAPES
in versatile Turks Head
4 GAGES
thickness with P & W electro-limit gage
5 BUNDLES
traverse wound coils, traverse wound spools, loose coils.
PRICE
UNDER $35,000
DELIVERY 10 WEEKS
Here is the new Fenn 5-in-1 Wire Line with a price as remarkable as its performance and compactness. It will produce precisely flattened or shaped, edged, and sized bundles at speeds up to 600 FPM in an absolute minimum of floor space. Inlet capacity up to 3/8" diameter. The Precision Fenn 8" Roller Bearing Rolling Mill has carbide shell rolls with internal and external cooling. The entire line operates from a single, infinitely variable speed AC motor with simple electric controls. The 5-in-1 Wire Line is engineered and built to Fenn quality standards. Write for complete specifications.

Personals . . .

Schrade F. Radtke has been named research director of a joint research program currently being initiated by the American Zinc Institute, Inc., and the Lead Industries Assoc. Dr. Radtke, chairman of the Richmond Chapter last year, was director of the metallurgical research laboratories of Reynolds Metals Co. at Richmond, Va., and also a lecturer on the staff of the research and development division of the American Management Assoc.

Rennie J. Swope is now metallurgist at the Manistee Iron Works, a division of Michigan Tool Co., Manistee, Mich.

Robert J. Dybas, following his release from the U.S. Army, has accepted a position as project engineer in the welding section of the process development laboratory of Aluminum Co. of America.

Harry H. Smith has retired from the Youngstown Sheet & Tube Co. A long-time A.S.M. member, he was chairman of the Cleveland Chapter in 1925.

A. C. Rucker was recently selected to take part in United Airlines special development training program for a period of 91 weeks.

Malcolm Hawkes has taken a position with Lockheed Missile Systems Div., Sunnyvale, Calif., as a materials and processes engineer, senior, in the firm's production engineering department.

Elmer Larved, alloy metallurgical engineer in the Chicago district of Youngstown Sheet & Tube Co. since 1935, has retired.

Robert W. Witty is currently chief mechanical engineer for Technicraft Laboratories, Inc., Thomaston, Conn.

John F. Ewing has been transferred to the Babcock & Wilcox Co. nuclear facilities plant at Lynchburg, Va., as manager of quality control. He was formerly metallurgical supervisor, research, at the company's tubular products division in Beaver Falls, Pa.

SPECIAL REPORTS ON FINISHING NON-FERROUS METALS

NUMBER I—Decorative, Corrosion-Resistant Finishing with Iridite

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a decorative finish or a good paint base for non-ferrous metals. However, continued developments are so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can combine salable appearance with durability in one finish at a competitive price advantage. Report II on paint base, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, as a basis for this discussion, a "decorative" finish is considered as any chromate film that is used as a final finish in itself. It may be truly decorative in that its sole purpose is to enhance the beauty of the product. For example, a bright chrome-like finish or a pleasing bronze appearance are among the many effects that can be obtained. It may be functionally decorative in that it reduces reflectivity for camouflage purposes or provides a means of color-coding parts. But, in all cases, the Iridite films protect the metal against corrosive attack.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. These films can produce a wide variety of pleasing appearances. The basic colors of the Iridite coatings are grouped below by metals.

ZINC and CADMIUM: Metallic bright, light iridescent, iridescent yellow, bronze, olive drab.

COPPER, BRASS, BRONZE: Metallic bright, yellow.

ALUMINUM ALLOYS: Clear, iridescent yellow, brown.

MAGNESIUM ALLOYS: Light brown, dark brown, black.

SILVER: Metallic bright.

In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

Depending upon the metal and the Iridite used, corrosion resistance of clear and bright films ranges from mild passivity to as high as 500 hours in salt-spray; on heavier dark films, salt-spray resistance ranges from approximately 100 to 1000 hours.

It is this combination of decorative and corrosion resistant properties that accounts for the widening use of Iridite finishes. For example, Iridites #4-73 and #4-75 (Cast-Zinc-Brite) make possible for the first time, a combination of lustrous chemical polishing of the as-cast surface of zinc die castings and good resistance to corrosion. Further, in many cases, sizeable savings in the cost of buffing and electroplating are realized.

On many steel parts, a simple system of zinc or cadmium plate and bright Iridite is used instead of more costly electroplated finishes to provide a bright, decorative and protective finish with tremendous savings in material, equipment and labor.

In finishing aluminum, where corrosion resistance or paint adherence is the prime consideration, the aircraft industry has all but abandoned the anodizing process in favor of recently developed chromate conversion coatings, among them Iridite #14 and #14-2 (Al-Coat). These formulations and their method of application can be varied to retain the original metallic appearance while providing acceptable corrosion resistance, or to produce a fully colored brown finish that offers exceptional corrosion protection. Again, time and manpower savings are astounding—one company saved at least $15,000 a year on maintenance of racks alone and another $40,000 on materials and labor in only nine months. In addition, of course, hundreds of thousands of dollars are saved by eliminating the need for expenditures for generators, heating equipment and racks.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to having decorative and protective functions, these chromate coatings form an excellent base for organic finishes and bonding compounds. They have low electrical resistance. Some can be soldered and welded. The Iridite film itself does not affect the dimensional stability of close tolerance parts.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 E. Monument Street, Baltimore 5, Maryland.

WHAT IS IRIDITE®

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

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CASTING
OPERATIONS
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THERMAL
LADLE HEATING BURNER

MANY COST-SAVING APPLICATIONS

The extreme high heat release rate of the THERMAL burner makes possible the application of this ladle heating installation without altering your existing facilities or production methods.

1. Reduces ladle pre-heating time as much as 75%.
2. Maintains pouring temperatures during continuous casting operations.
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QUICK, ECONOMICAL INSTALLATION

THERMAL ladle heating installations are available complete with ladle covers or ready for mounting to your present cover. All necessary valves, blower, pump, etc., are supplied for immediate application.

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Thermal Research & Engineering Corp.
CONSHOHOCKEN • PENNSYLVANIA
REPRESENTATIVES IN PRINCIPAL CITIES

Personals . . .

George Stern has joined the Nuclear Development Corp. of America, White Plains, N. Y., as manager of the materials department. Prior to assuming the NDA post, he was technical director of American Sinsteel Corp. for four years.

Robert J. MacDonald has been appointed head of the bearing and friction materials section of the division of mechanical research, Clevite Research Center, Cleveland. He joined the Research Center as a senior metallurgist in 1956 and before that was associated with Battelle Memorial Institute.

Robert T. Morelli has been appointed supervisor of specifications and technical information for Crucible Steel Co. of America's metallurgical division in Pittsburgh. Formerly staff metallurgical coordinator in the company's central metallurgical office, he joined the company in 1947 at the general sales department in New York.

D. E. Lehane, formerly manager of sales engineering, was recently named director of customer relations for Chromalloy Corp., White Plains, N. Y.

S. P. Gaston, who joined the Kidd Works of the Vulcan-Kidd Steel Div., H. K. Porter Co., Inc., Aliquippa, Pa., in 1950, has been promoted to special shape engineer.

John E. Sabel has been transferred from Seattle, Wash., to Los Angeles in the scientific instrument division of Bausch & Lomb Optical Co., Rochester, N.Y.

Alan C. Mattison, president, Mattison Machine Works, Rockford, Ill., has been elected first vice-president of the National Machine Tool Builders' Assoc. at its annual meeting in Hot Springs, Va.

R. L. Kenyon, former associate director of structural design and administration, research division, Armco Steel Corp., Middletown, Ohio, has been promoted to assistant to the vice-president, research. He has served as an associate director of Armco research since 1940, joining the company in 1920 after graduating from Purdue University.

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Personals . . .

Edgar H. Dix, Jr., recently retired as assistant director of research, Aluminum Co. of America, has been awarded the Distinguished Public Service Award by the U. S. Navy, its highest civilian honor, for his outstanding contributions to the Navy in the fields of scientific research and development.

James P. Gill has been elected chairman of the Board and president of Vanadium-Alloys Steel Co., Latrobe, Pa. Mr. Gill, who joined the organization as a research metallurgist in 1920, has served as president since 1953.

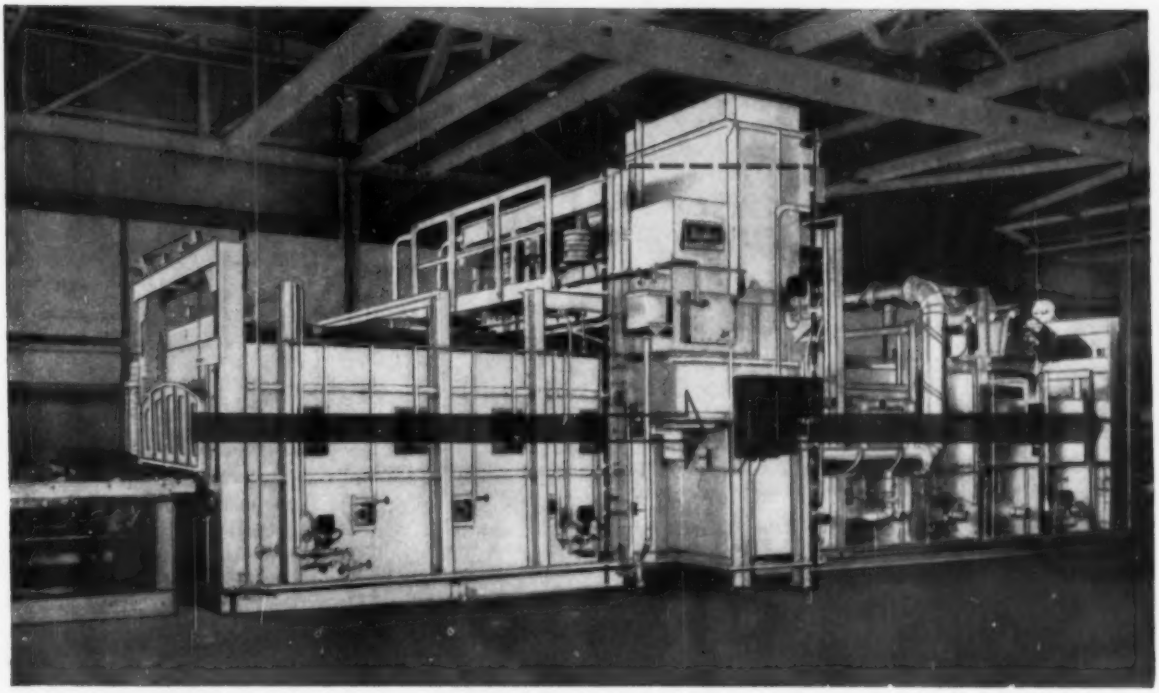
Leo I. Dana and **David Swan** have been named vice-presidents of Linde Co., a division of Union Carbide Corp. Mr. Dana, as vice-president, technology, will evaluate Linde's technical program while Mr. Swan, as vice-president, research, will be responsible for the research and development activities of Linde's laboratories in Tonawanda, N.Y., and Speedway, Ind.

Normal L. Deuble has been relieved of his duties as manager of metallurgical development for Climax Molybdenum Co., a division of American Metal Climax, Inc., New York, to devote full time to the creation and direction of the metallic molybdenum development and service division. His former position will be filled by **Walter F. Craig, Jr.**, who has been associated with the company for eight years. He will transfer his headquarters from Pittsburgh to New York.

Joseph H. Brennan, chief metallurgist of the Electro Metallurgical Co., Niagara Falls, N. Y., was awarded the Frank J. Tone Medal Award by the Niagara Frontier Section of A.I.M.E. The medal, awarded annually, is presented to a person who has made outstanding and important contributions to the science and practice of metallurgy.

Arthur C. Buesing has been named vice-president, foundry sales, for the Brown Thermal Development Co., Elyria, Ohio. He was affiliated with the Gray Iron Research Institute of Columbus, Ohio, before taking his new post.

Superfast cooling for cycle annealing



A furnace-within-a-furnace makes this Surface cycle annealer one of the most versatile heat treat units in the country. It anneals, cycle anneals, and normalizes gear forgings of different size, shape, and alloy at the net rate of 864,000 lbs. per month or better.

Such exceptional versatility is achieved by a superfast cooling zone. Really a full convection furnace within a direct-fired furnace, this zone is isolated by refractory doors. It can be used or by-passed, depending on which of many cycles the customer wants. As a result, the customer can heat treat as many as 13 different alloys in this one furnace.

Adding to the flexibility of the furnace is a modular tray design. Each module is an 18x20-inch chrome alloy casting. Modules can be combined to hold any size of work up to 800 pounds. They are also used to carry work outside the furnace.

This furnace-within-a-furnace is another proof that Surface engineers are old hands at creating new ideas in heat treating.

Write for Bulletin SC-146 on cycle annealing.

Surface Combustion Corporation, 2377 Dorr St., Toledo 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ontario.

Surface

wherever heat is used in industry

M-3 Arcweld Creep Rupture Tester, custom designed for labs which test smaller size specimens or use lighter loads.

For accurate creep rupture testing choose from 8 ARCWELD models

Wherever there's a need for accurate, economical creep rupture testing, the answer to that need is performance-proved creep rupture testers from Arcweld Manufacturing Co.

Choose from 8 compact, easy to operate, low maintenance Arcweld models. Capacity ranges from 6,000 to 30,000 pounds. Oversize Arcweld furnaces produce stable temperature up to 2,200 degrees maximum at no additional cost. Exclusive automatic beam leveling control: no matter how far the sample stretches, beam remains level.

Other products: eight-station rotary furnace jigs for hot tensile testing, master control panels, twelve-furnace Universal heat treat units and instrument cabinets.

Hundreds of thousands of hours of lab performance have proved Arcweld testing machines to be the *logical* choice. Clip this coupon or write on your business letterhead to Arcweld Manufacturing Co. today for more information and a complimentary Arcweld Creep Load Calculator.

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Phone 1470

Please send more information about Arcweld testing equipment. Have a salesman call ☐

Name _____ Title _____

Company _____ Principal Products _____

City _____ State _____

Personals . . .

John A. Alexander recently left the staff of the Metals Research Laboratory at Carnegie Institute of Technology to join the metals research section of Watertown Arsenal, Watertown, N. Y., as a research metallurgist working on metallic bonding.

Jerry B. Minter is in charge of the new nuclear instrument division of Components Corp., Danville, N. J. He has been actively associated with Components Corp. since 1953 and prior to that was vice-president and chief engineer of Measurements Corp. until it was merged with McGraw-Edison.

Hamnett P. Munger, chairman of the department of chemical and metallurgical engineering at Syracuse University, has been named head of the metallurgical division at the new Republic Steel Corp. research center in Independence, Ohio.

Irving Whitehouse has been assigned to the new Republic Steel Corp. research center in Independence, Ohio, as assistant director of research. Affiliated with Republic since 1935, he last held the position of manager of process and product development division of Republic. At the same time **W. A. Black**, chief engineer of the steel and tubes division of Republic, has been appointed assistant director of research of the Republic Electro-Mechanical Research Center in Cleveland. Mr. Black was recently awarded the De Forest Award at the annual meeting of the Society for Nondestructive Testing in Cleveland. Sponsored jointly by the Society for Nondestructive Testing and Magnaflux Corp., the award is given annually for outstanding contributions in nondestructive testing.

Paul P. Ventura has resigned as vice-president, general manager and director of both Eastern Metals Industries and Eastern Heat Treating and Brazing Corp., Glen Cove, L. I., N. Y., to accept a staff engineering position with Aerojet-General Corp. As technical specialist he will serve as consultant and engineer in mechanical and metallurgical areas and in research and development in the solid rocket plant.

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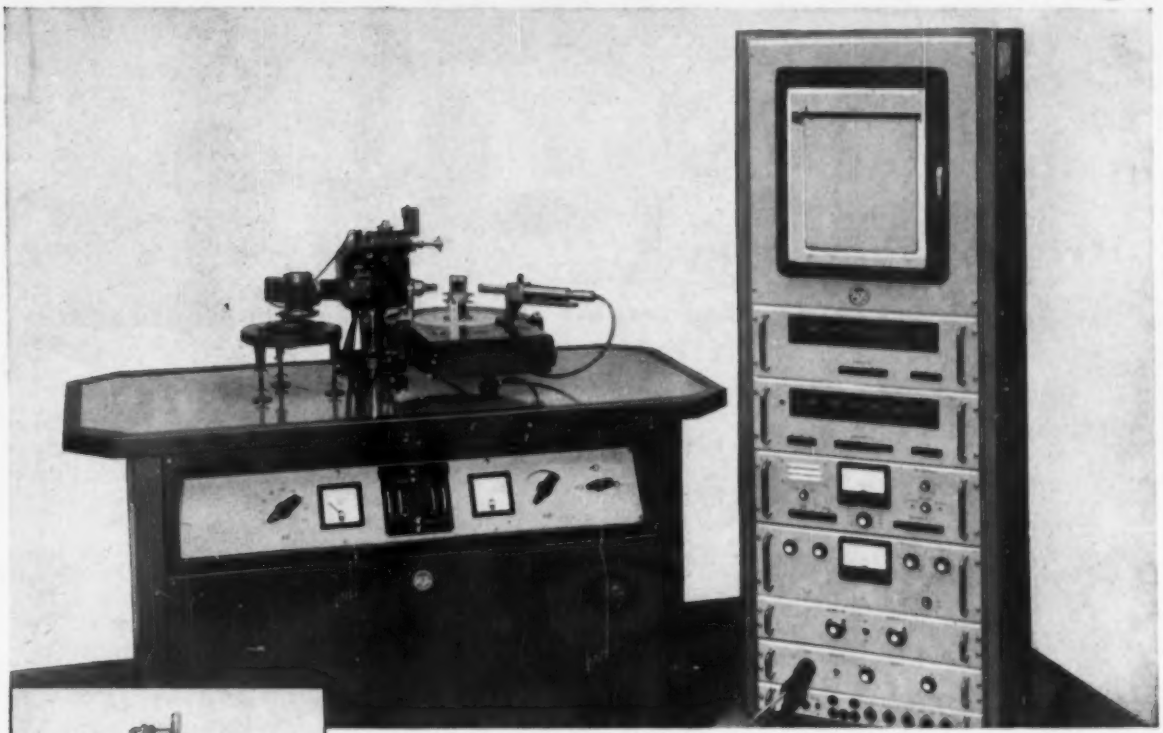

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Metals Engineering Digest

. . . Interpretative Reports of World-Wide Developments

High-Temperature Metallurgy

Notes on the Third International Plansee Seminar held in Reutte, Tyrol, Austria, June 22 through 26, 1958. This supplements the article by D. A. Robins on p. 84 of this issue of *Metal Progress*.

One of the most severe handicaps in expanding the utilization of high melting point metals is their affinity for interstitials and ease of oxidation. Work being done to understand these difficulties and overcome them was reported at the Seminar. Georg Brauer and Horst Müller of the University of Freiburg, Freiburg, Germany, discussed structures of newly discovered tantalum and columbium suboxides and hydrides. Erich Gebhardt and H. D. Seghezzi, Max-Planck-Institut, Stuttgart, Germany, reported on comprehensive investigations of the tantalum-oxygen and tantalum-nitrogen systems, respectively. Both of these studies were the first thorough investigations where the gas-metal reaction products and the relation of these to mechanical and other properties of this metal were determined.

The deleterious effect of oxygen in columbium was investigated and attempts to overcome the difficulty through alloying were reported by R. I. Jaffee, Battelle Memorial Institute, Columbus, Ohio. He stated that on the basis of oxidation studies at 600, 800 and 1000° C. zirconium and titanium markedly reduce the depth of oxygen contamination, while chromium and vanadium were most effective in reducing oxygen diffusion in columbium. The alloying approach was utilized to improve workability of molybdenum.

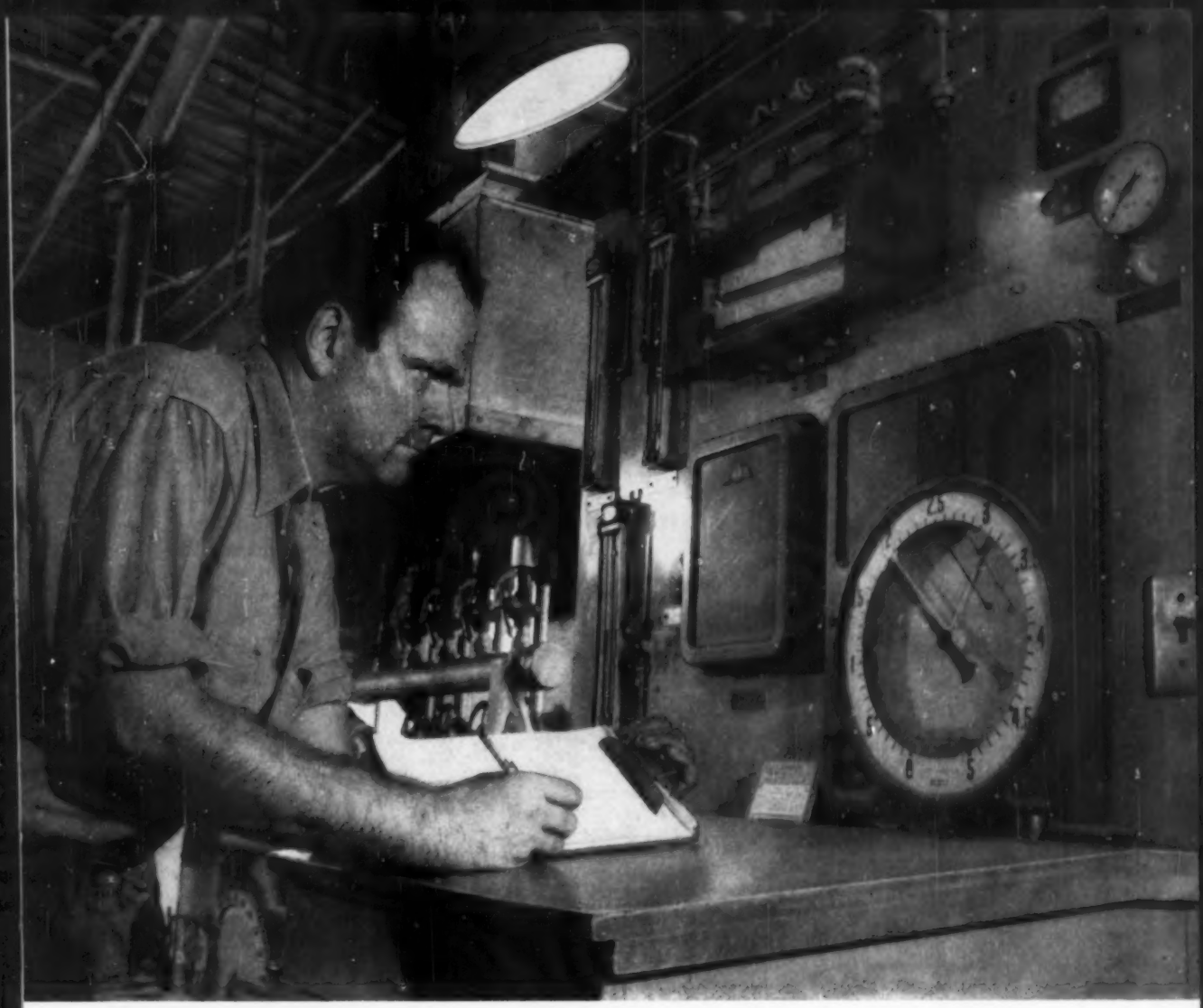
An increase of 50 to 110 ppm. oxygen reduces ability to roll molybdenum from 95 to 56%. A remarkable improvement in workability is obtained by addition of 50% rhenium. It was also shown that a molybdenum-rhenium alloy can contain up to 500 ppm. oxygen in as-cast condition and still be hot workable. When 30% rhenium is added to tungsten, its ductility is improved.

Molybdenum Coating – Helmut Bückle, Organization National de Recherches Aerodynamiques, Paris, spoke on protection of molybdenum alloys against oxidation. He stated that while the development of an all purpose coating was hardly possible, coatings for specific applications and temperature ranges are available or can be expected to become so in the near future. Of particular value is a coating consisting of chromium followed by nickel which protects for 500 hr. at 1000° C. For shorter service life, coatings based on ceramics should be useful. Although not directly applicable universally, some interesting possibilities with ceramic-base coatings were reported by Erich Fitzer, Siemens, Meitingen b. Augsberg, Germany, who also told about the development of molybdenum silicide coatings for resistance heating elements useful in air for temperatures over 1600° C.

Alloy Studies – The quest for new alloys invariably begins with phase diagram studies, and several alloy investigations were reported. Horst Braun, Richard Kieffer, and Karl Sedlatschek, Metallwerk Plansee A.G., Reutte, Austria, reported on the tungsten-tantalum system, discussing essential properties of alloys across the phase diagram produced both by sintering and arc melting. A. G. Knapton, A.E.I. Research Laboratory, Aldermaston, England, reported on the rhenium-silicon system on basis of X-ray and metallographic studies. Three intermetallic compounds, ReSi, $ReSi_2$ and Re_5Si_3, all with melting points below 2000° C., were found.

Dispersion hardening has become an important approach for high-temperature alloy development. By this means high-temperature properties, in particular creep and creep rupture of metals, such as aluminum, magnesium, molybdenum and tungsten, are improved by dispersion of ultra fine particles of a second phase. This strengthening is attributed to the retardation of secondary recrystallization and grain-growth phenomena by suitable second-phase distribution. W. M. Schwarzkopf, Schwarzkopf Development Corp., Yonkers, N.Y., showed some of the possible improvements and the great promise that this method holds.

Nuclear Applications – Seldom a metallurgical meeting takes place today, without mention of the interrelation between materials and nuclear energy. One paper reported on compatibility of molybdenum, tantalum and columbium with liquid bismuth and bismuth-uranium solutions. Static and some dynamic testing data in the 200 to 1000° C. range were reported. Tantalum and molybdenum showed up quite well to 800° C. on dynamic testing while columbium seems to behave rather poorly at 1000° C. under static condition. R. I. Jaffee reported on work on the performance of refractory metals in liquid sodium and sodium-potassium systems with find-



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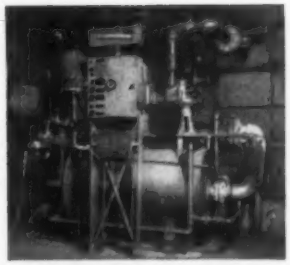

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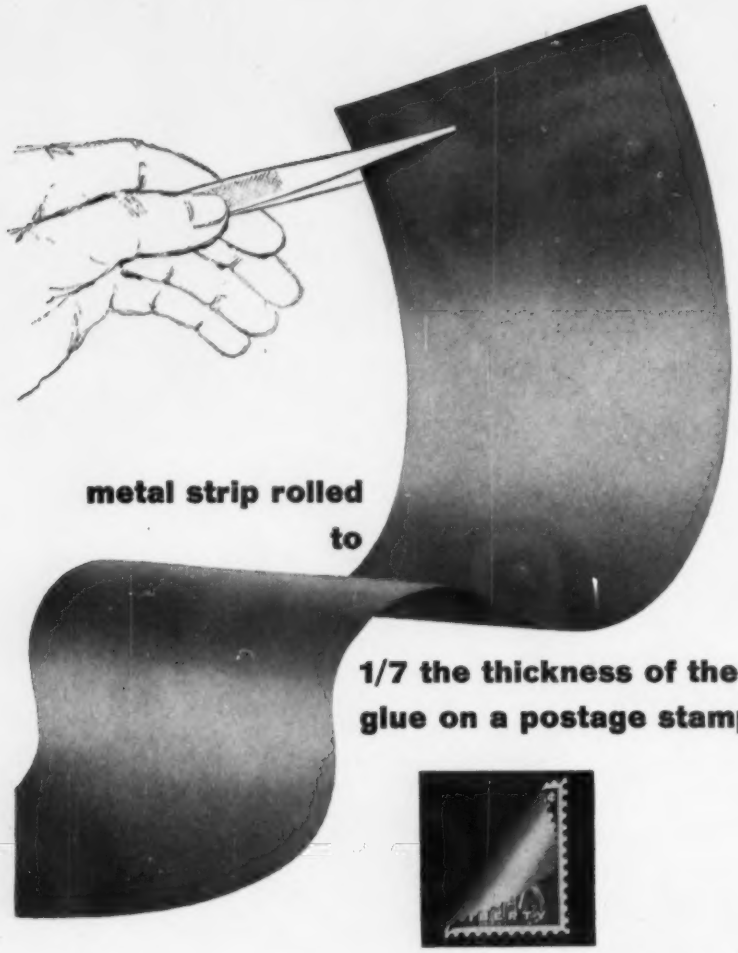

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High Temperature . . .

ings singling out molybdenum in every respect. Another report on refractory metals impregnated with uranium points to some interesting future developments for nuclear applications using this approach.

Future Areas – N. E. Promisel, Bureau of Aeronautics, and Julius J. Harwood, Office of Naval Research, Washington, outlined new areas from which the high-temperature materials to serve the future of nuclear energy and interspacial vehicles will come. They may well be themes of future Plansee Seminars:

1. Fine particle strengthening – The extension of the SAP principle to high-temperature metals.
2. Metal whiskers – The initiation of a new field of fiber metallurgy aimed at the practical utilization of the high strengths approaching theoretical strengths observed in thin whiskers.
3. Ductile ceramics – Recent work on single-crystal ceramics looks encouraging and the preparation of ductile polycrystalline ceramic materials is a possibility.
4. Composite materials – These utilize the different materials of the composite to best advantage.
5. Property improvements utilizing new processing techniques.

ROBERT BAKISH

Powder Metallurgy of Nuclear Materials

Digest of "Powder Metallurgy at the Atoms-for-Peace Conference", a report presented by Henry H. Hausner at the A.I.M.E. Powder Metallurgy Committee Meeting, Cleveland, Oct. 30, 1958.

MOST of the recent powder metallurgy development work on fabrication of reactor components concerns the heart of the reactor—the nuclear fuel element. Three different types of solid nuclear fuel come into the picture: metallic, ceramic and cermet-type elements.

H. Lloyd and J. Williams, of the United Kingdom Atomic Energy Authority in Harwell, investigated powder metallurgy production of uranium for fuel rods. Attention was concentrated almost exclusively on the consolidation of powder pro-

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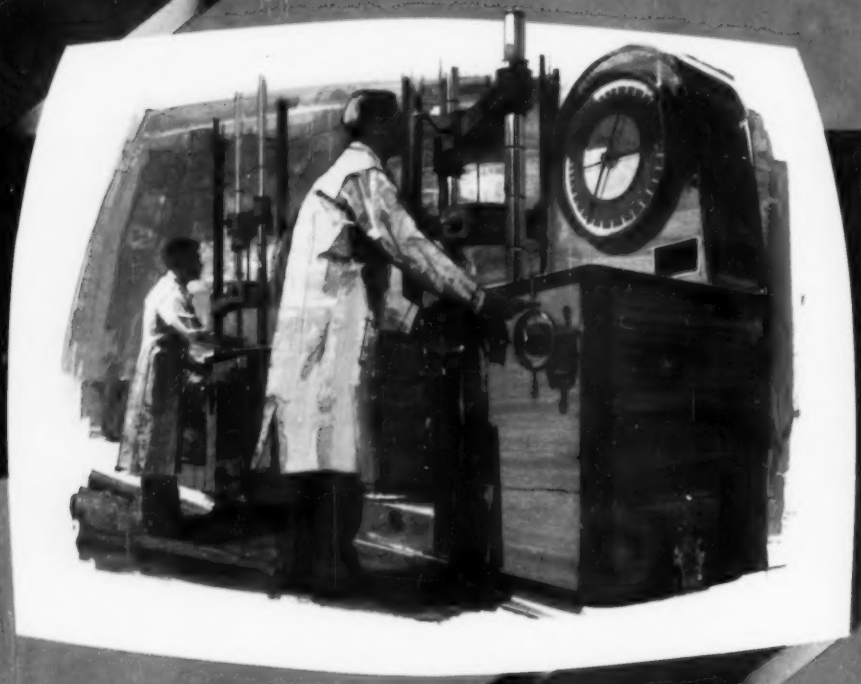

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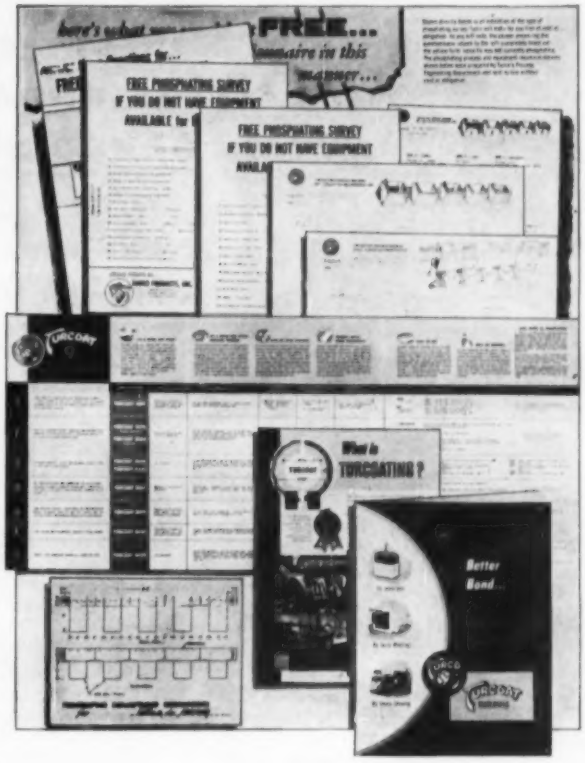

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Powder Metallurgy . . .

duced by calcium reduction of uranium dioxide. This type of uranium powder seems to be considerably more stable in air than when formed by the hydriding of massive uranium. The Harwell engineers claim that the handling of this powder in dry boxes containing inert atmosphere is not necessary. This calcium-reduced uranium powder is spheroidal in shape, and 90% of the material is smaller than 60 microns. The powder can be pressed and subsequently sintered or hot pressed below the alpha-to-beta phase transformation temperature. Extrusion of these powders is also possible; however, this can be done only in the gamma phase (above 774° C.), where the plasticity of the metal is high enough for the process.

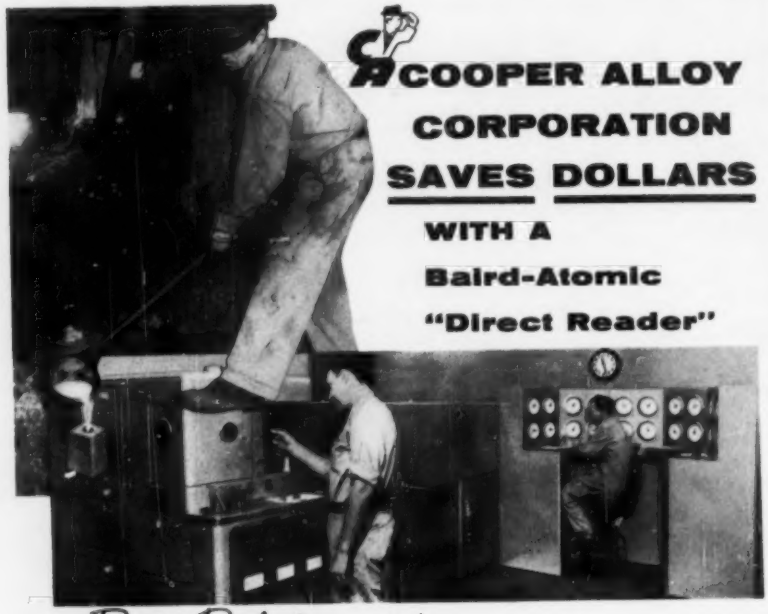
Thorium – S. K. Kantan, R. V. Raghaven and G. S. Tendolkar of the Atomic Energy Establishment of Trombay, India, investigated the powder metallurgy of thorium. This metal is increasing in importance as a secondary fuel for nuclear reactors. Previous studies indicated that fabrication of thorium by cold compacting and sintering is possible. Compacting of the powder was done at pressures ranging from 10 to 50 tsi.; sintering was carried out at 1200° C. for 1 hr. in vacuum.

Co-reduction of Oxides – Uranium alloy powders were developed by direct reduction of oxides, as reported by R. H. Myers and R. G. Robins, of New South Wales University of Technology, Kensington, Australia. The process uses co-reduction of mixtures of uranium dioxide and alloy element oxide with calcium in a sealed reaction vessel. The powder produced has a wide variation in particle-to-particle composition, although of consistent composition for various size fractions. Reduction of compound oxide with calcium does not seem to be very suitable. The alloy systems investigated were uranium plus nickel, chromium, molybdenum and columbium. Uranium-molybdenum and uranium-columbium powders, especially, seem to be useful for the production of dimensionally stable fuel elements.

Fuel Element Trend – There is a trend in reactor fuel technology to use uranium compounds instead of metallic materials. It seems that the oxides and carbides of uranium, especially, have many advantages over metallic uranium. The main characteristics of ceramic fuel materials are high melting temperature, no destructive phase changes, practically no radiation effects, and high corrosion resistance.

It seems that the two main disadvantages of ceramic fuel and ceramic materials in general, namely, lower heat conductivity and low temperature shock resistance, are rather unimportant compared with the great advantage that they can be operated at considerably higher temperatures. High-temperature nuclear reactors are desirable on account of better efficiency and greater economy. At the present time, many reactors have uranium dioxide fuel elements prepared from UO_2 powders by compacting and sintering.

The physical properties of uranium dioxide are being studied by many



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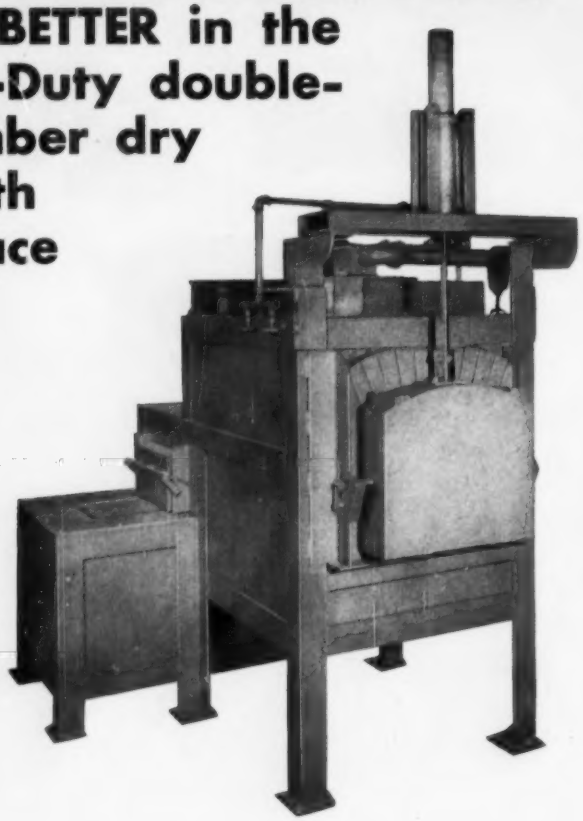

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Powder Metallurgy . . .

investigators in various countries; however, Dr. J. Belle's (Westinghouse, Bettis Field) presentation at Geneva represents probably one of the most carefully made studies of this type. The literature on uranium dioxide has grown very fast; more than 300 papers on this subject have been published during the last few years.

Uranium Carbides – In developing uranium compounds, one has to consider not only the melting temperature, but also the uranium content per unit volume. From this standpoint, uranium monocarbide offers some advantages, inasmuch as it contains many more uranium atoms than does uranium dioxide. Much effort is being concentrated on the development of uranium carbide fuel elements. (See *Metal Progress*, July 1958, p. 65.)

A. Boettcher of Degussa, Frankfurt, Germany, described fuel elements to be used in the gas-cooled German reactor, consisting of compacted uranium monocarbide inserted in a graphite sphere. Charging and discharging the reactor with this spherical fuel is advantageous in many respects.

High-density fuels made either from uranium monocarbide or a cermet composed of uranium carbide-uranium have been prepared at the Saclay Research Laboratories of the French Atomic Energy Commission. The cermet was fabricated by hot pressing mixtures of uranium powder and graphite in suitable proportions. Compacting was carried out at a pressure of 25 tsi. at 1000° C. for 3 hr.

A similar fuel was developed in the U.S.S.R., however not by compacting of powder mixtures, but by infiltration of uranium with a compacted skeleton of uranium monocarbide. In the official exhibition in Geneva, the U.S.S.R. showed fuel elements consisting of uranium-molybdenum alloy powder particles dispersed in a matrix of magnesium powder and densified by compacting and sintering. This kind of fuel was used in the first Russian reactor which has been in operation for more than three years.

Cermets – The most common cermet mixtures in reactor technology use uranium dioxide particles as dis-

persants in a matrix of either aluminum, zirconium or stainless steel. Pioneering work in this type of long-life fuel element has been done at Oak Ridge National Laboratory by J. E. Cunningham and R. J. Beaver. The problem of inserting a brittle material in a ductile matrix can be solved only by powder metallurgy. It is important that the dispersed particles are not too fine with respect to the metallic matrix. If so, they may form a continuous matrix which may impair the mechanical properties of the mixture and have undesirable effects on the distribution of fission gases produced during reactor operation.

Plutonium Cermets – P. Murray and J. Williams of the United Kingdom Atomic Energy Authority at Harwell discussed their work on the insertion of plutonium compound particles in a metallic matrix as a good possibility for the future. Whereas matrix materials for uranium dioxide are limited to just a few metals of rather low neutron absorption cross section, this limitation does not necessarily apply to plutonium cermet fuels. Therefore matrix materials such as molybdenum, vanadium, columbium, nickel, or even titanium or tantalum may be taken into consideration.

R. Kiyoura and T. Sata of the Tokyo Institute of Technology are investigating another kind of dispersion-type element, made by dispersing uranium silicide in molybdenum disilicide. The uranium silicides were made by sintering a mixture of uranium and silicon powders. Both materials, the USi and $MoSi_2$, were then mixed in powder form, compacted and sintered at 1450° C. or hot compacted at 1300° C.

Interesting types of fuel also were obtained by the solid solution of uranium dioxide and thorium dioxide in powder form, to be used as a dispersant. This solid solution of the two oxides was originally developed at Argonne National Laboratory, and has proved to be an excellent fuel. The insertion of this solid solution into various matrixes offers many possibilities. Beryllium oxide has been considered by the Japanese engineers to be a good matrix material, because a fuel element of this type combines fuel and moderator in one single unit.

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Powder Metallurgy . . .

elements was exhibited at the British Exposition at Geneva; it is a tubular element consisting of uranium fuel clad with beryllium. This beryllium, made at Aldermaston, England, and described by T. R. Barrett, G. C. Ellis and R. A. Knight, is ductile in all three directions of the crystallographic axis. This beryllium is also a powder metallurgy product; however, it's not made by pressing the powders, but by sintering loose beryllium particles close to the melting temperature of the material – a technique which permits fabrication of tubes for fuel cladding purposes.

There is a general trend to apply powder metallurgy more and more for the production of nuclear materials and components, and indications are that powder metallurgy will continue to grow in this field.

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Welding Reactive Metals

Digest of "Equipment for Welding Reactive Metals", by A. Mombrun and W. G. Hull, *Welding and Metal Fabrication*, Vol. 26, January 1958, p. 9-11.

EQUIPMENT has been developed at the British Welding Research Assoc. laboratories for arc welding titanium and zirconium-base alloys and possible future work on other metals, such as columbium, tantalum, and vanadium. The equipment provides for welding under contamination-free conditions for evaluation and providing control specimens.

Welding is performed in a rectangular chamber of about ½ cu.ft. with access at either end. Closure is made by bolting plates to flanges. The chamber is directly connected to an oil diffusion pump capable of producing a vacuum of 10^{-4} mm. mercury in 15 min. All demountable joints use "O" ring seals on seats which have been carefully polished to remove all but the finest circumferential scratches.

The torch is stationary with observation windows on each side of the chamber. The only parts projecting into the chamber are the electrode and nozzle (if used). The brass torch has ceramic rather than plastic or resin-bonded insulation. Restricted vertical movement for presetting the arc gap and touch starting is possible through a bellows arrangement. The torch is air-cooled with a safe maximum current of 150 amp. in a ⅛-in. diameter electrode although a heavier duty torch can be fitted.

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Shielding gases can be introduced through the torch or through the chamber wall. Contamination is avoided by insuring a leakproof supply system from the bottle and by minimizing impurities from the welding equipment itself. The latter can be minimized by periodic degreasing of the chamber and its contents and by handling work and fixture with rubber gloves.

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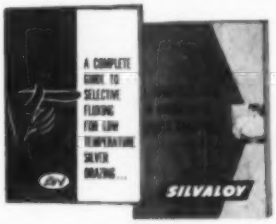

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Cyclosteel

Digest of "Steelmaking Since Bessemer", by Sir Charles Goodeve, *Journal* of the Iron & Steel Institute, October 1956, p. 113.

THE COMPLETE TEXT of this article was given as a presidential address to the Chemistry Section of the British Assoc. for the Advancement of Science by Sir Charles Goodeve at the August 1956 meeting, and discussed steel manufacture from the standpoint of high-temperature chemistry, for an audience of chemists rather than metallurgists.

The author noted that the reduction of iron ore with carbon "over-reduced" the mixture so the result was pig iron with 4% carbon and all the phosphorus in the charge. Prior to Bessemer, this pig iron was refined into wrought iron in a puddling furnace, wherein the just-molten pig iron is stirred with a slag high in iron oxide, the latter removing carbon while the remaining purified iron solidifies as small crystals — low-carbon iron having a higher melting point than high-carbon iron. The same reaction is used in the openhearth furnace, but the product is molten steel since the furnace is 700° F. hotter. The reactions are correspondingly faster.

Bessemer supplied the necessary oxygen for refining by blowing air into molten pig iron, and the speed is at least eight times that in the openhearth because of the inherently higher rate of mixing of reactants and diffusion of products. Unfortunately, phosphorus is not removed; in the language of the modern physical chemist, "the chemical potential of the phosphorus at operating temperature is lower than that of carbon or of iron". Some 20 years later, Thomas found a solution of this problem: In the Thomas or basic bessemer process, the P_2O_5 is removed from the metal by a basic slag. Sir Charles comments, perhaps ruefully: "This British invention allowed the industrial revolution to spread to countries in Europe and brought them into severe competition with this country."

Modern adaptations have been the bessemer blowing with enriched oxygen or with a low-nitrogen blast* to produce low-carbon, low-nitrogen

*See *Metal Progress*, January 1957, p. 67.

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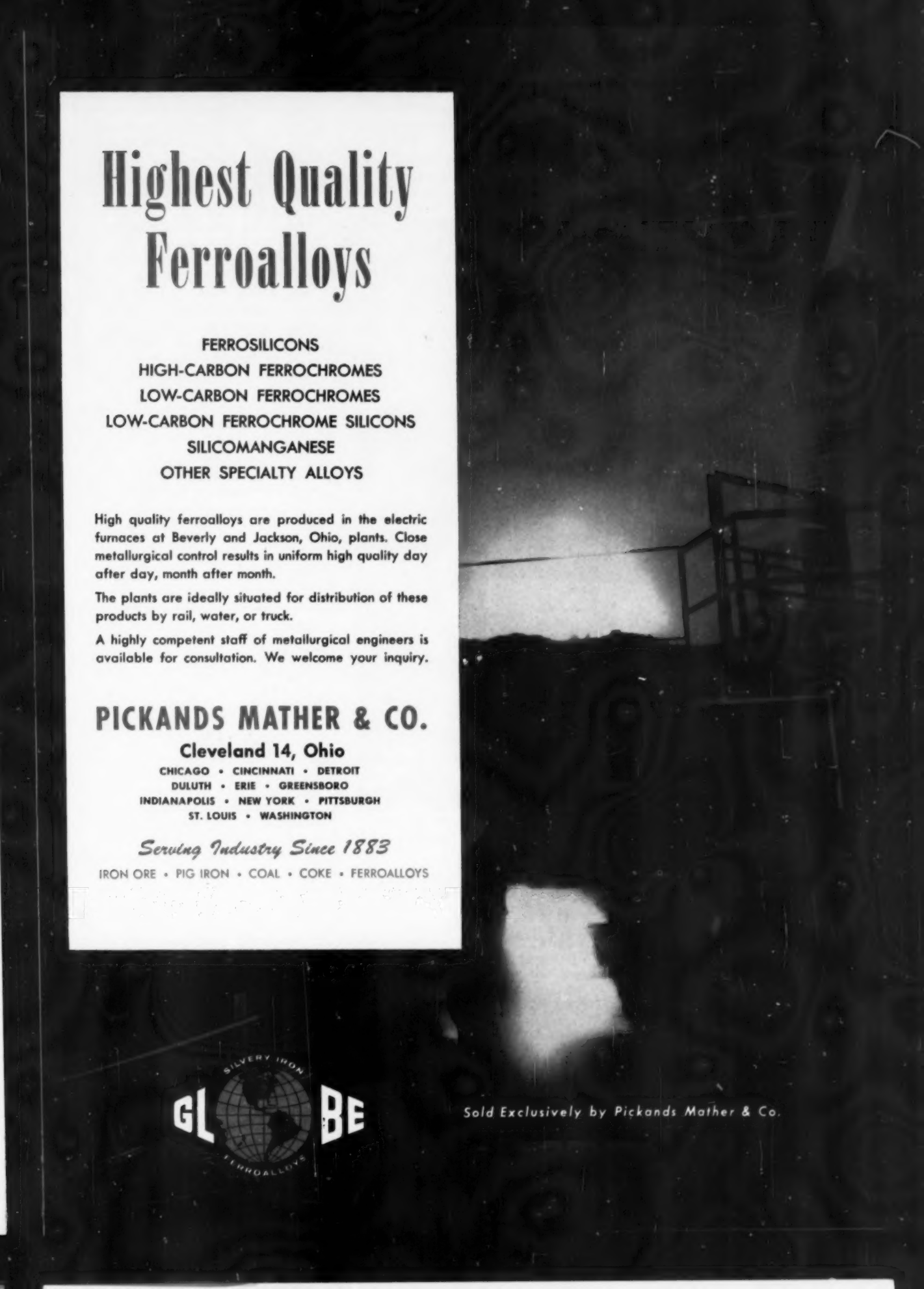

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Cyclosteel . . .

steel and "giving the steelmakers a new degree of freedom in being able to change the blast at will." There is also the Austrian top-blown oxygen converter ("L-D" process)* having important scientific interest in that phosphorus is removed ahead of or simultaneously with the carbon – primarily because the oxidation of the two occurs in regions intimately in contact with slag; while the slag readily absorbs the P_2O_5, it has practically zero solubility for CO.

Cyclosteel – In looking into the future, Sir Charles noted the many attempts to reduce ore to iron direct. Sponge iron† has been made commercially for a long time and the American "H-iron"‡ was mentioned. These give good feed materials for making steel, but are not direct *steelmaking* processes.

"We have seen that the speed of Bessemer's process came about through the dispersion of air bubbles in a liquid metal. Similar speed potentialities would exist if we reversed this system and dispersed small droplets of liquid ore in a high-temperature gas. Furthermore if this gas could be maintained at a low oxygen potential, the ore droplets would be reduced to droplets of liquid metal plus slag. If the oxygen potential is controlled at the correct low value and lime is introduced for the slag, neither silicon, carbon nor phosphorus need come into the metal and thus the droplets would be a form of steel rather than pig iron. Finally, it would be necessary to precipitate the droplets out of the gas and allow the metal to separate from the slag by gravity and surface tension."

Such a process, called "cyclosteel," is being intensively studied by the British Iron and Steel Assoc., where small quantities of very crude *steel* have been made. The fine ore will be preheated – probably in a fluidized bed – to the verge of stickiness and injected into reducing gas. Atomized fuel, partially burned in oxygen, will produce gas of the necessary high temperature and low oxygen potential. The two reactions coal + O_2 + CO_2 → CO and ore + CO → Fe + Slag + CO_2 are very fast at the correct temperature, and consequently ore fines are reduced in a very short time.

"The separation of the gas from the precipitated products will take place by gravity and cyclonic centrifugal action, and a settling chamber will finally separate the iron from the slag.

"It is seen that the Cyclosteel process is an 'inversion' of Bessemer's process in both a physical and a chemical sense." It is extremely attractive economically, "especially as it avoids the sinter plant and the coke ovens and widens the range of fuels that could be used. It is unlikely to replace the blast furnace, at least for many years, but if logic can be converted into practice, it will take a place among pneumatic steelmaking process." E.E.T.

*See *Metal Progress*, January 1958, p. 72.

†See *Metal Progress*, May 1950, p. 631 and March 1953, p. 67.

‡See *Metal Progress*, March 1958, p. 92.

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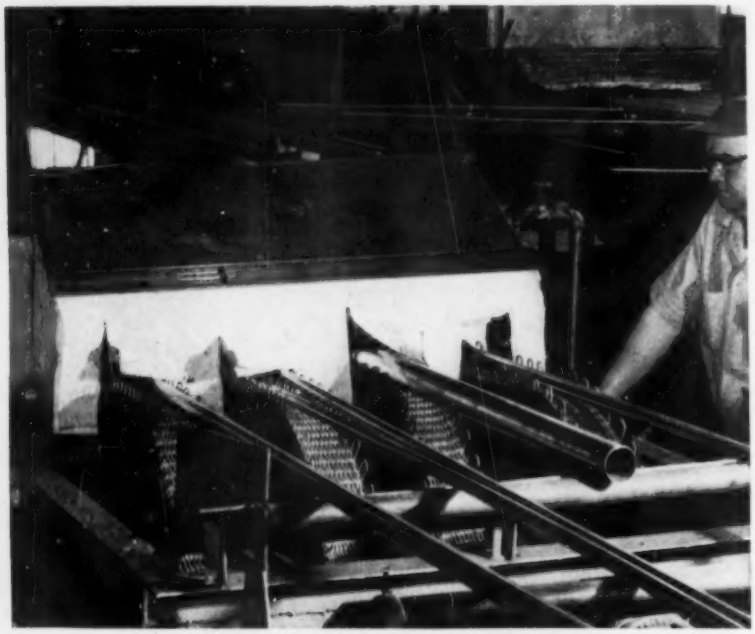

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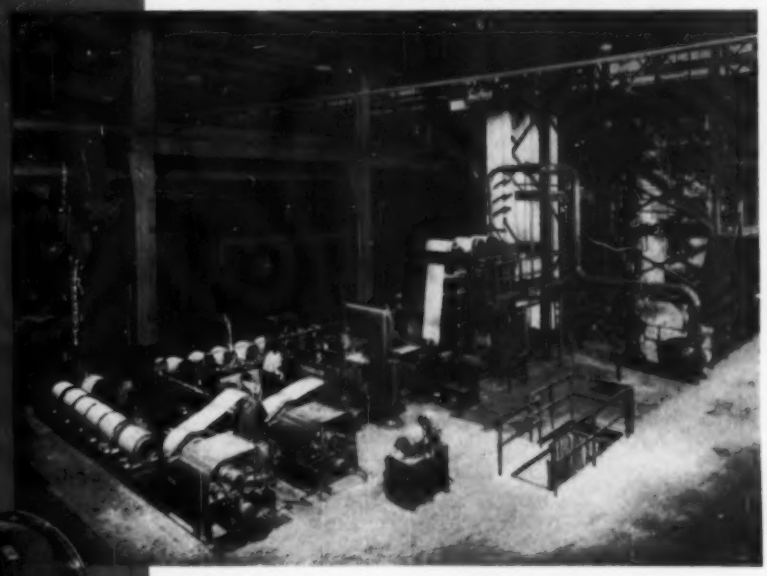

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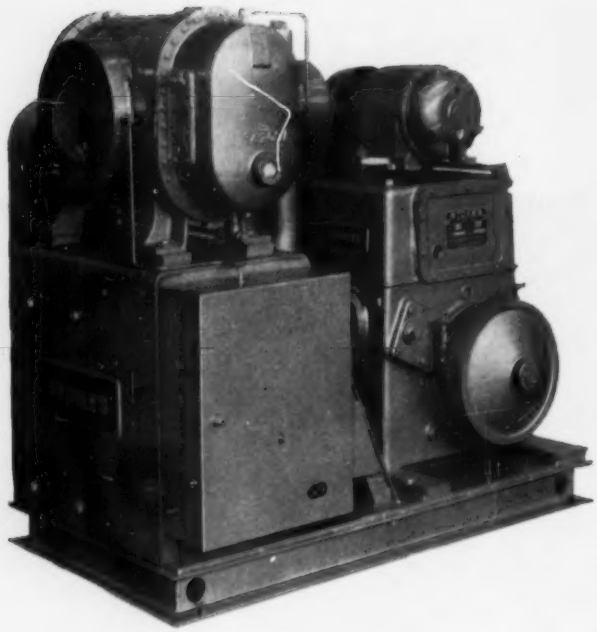

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Heat Treating Malleable Iron

Digest of "Development of a Method of Heat Treating Malleable Iron in a Swedish Foundry", by Hans Weber, *Gjuteriet*, Vol. 47, August 1957, p. 166-172.

THE IMPORTANT ADVANTAGES of heat treated malleable iron have been recognized for many years. In the United States especially the development of several grades of pearlitic malleable was hailed by designers.

In Sweden the agricultural industry provided the needed impetus for much research on malleable iron, since mechanical components should be highly wear resistant. The important phases of development at the author's plant were concerned with the proper selection of raw materials, metallographic characteristics, heat treating practice and melting cycles.

In selecting raw materials, care is needed to prevent excessive amounts of trace elements, especially copper, chromium and vanadium. The accumulation of these undesirable "tramps" may cause serious difficulties on malleablization.

For the past five years, spectrographic analysis has been used to check heats during meltdown. Adjustments can be made within 20 min. of sampling.

The hard iron castings can be removed from the molds quickly, which is beneficial with respect to the number of temper carbon nuclei formed. A decrease in the rate of cooling also markedly decreases the nuclei in the matrix which renders any decomposition of cementite more difficult on annealing later on. The economic aspects of the malleable iron process can be markedly affected by the acceleration of the decomposition of cementite. An investigation of the effects of boron led to the development of the quick anneal method and is traced to a large amount of nuclei.

While the conventional malleablizing cycle in batch-type oil-fired furnaces took up to 75 hr., resulting in a fully ferritic structure, attainment of a pearlitic matrix requires far less time and can be accomplished in 42 hr. if the correct equipment is used. (*Cont. on p.* 158)

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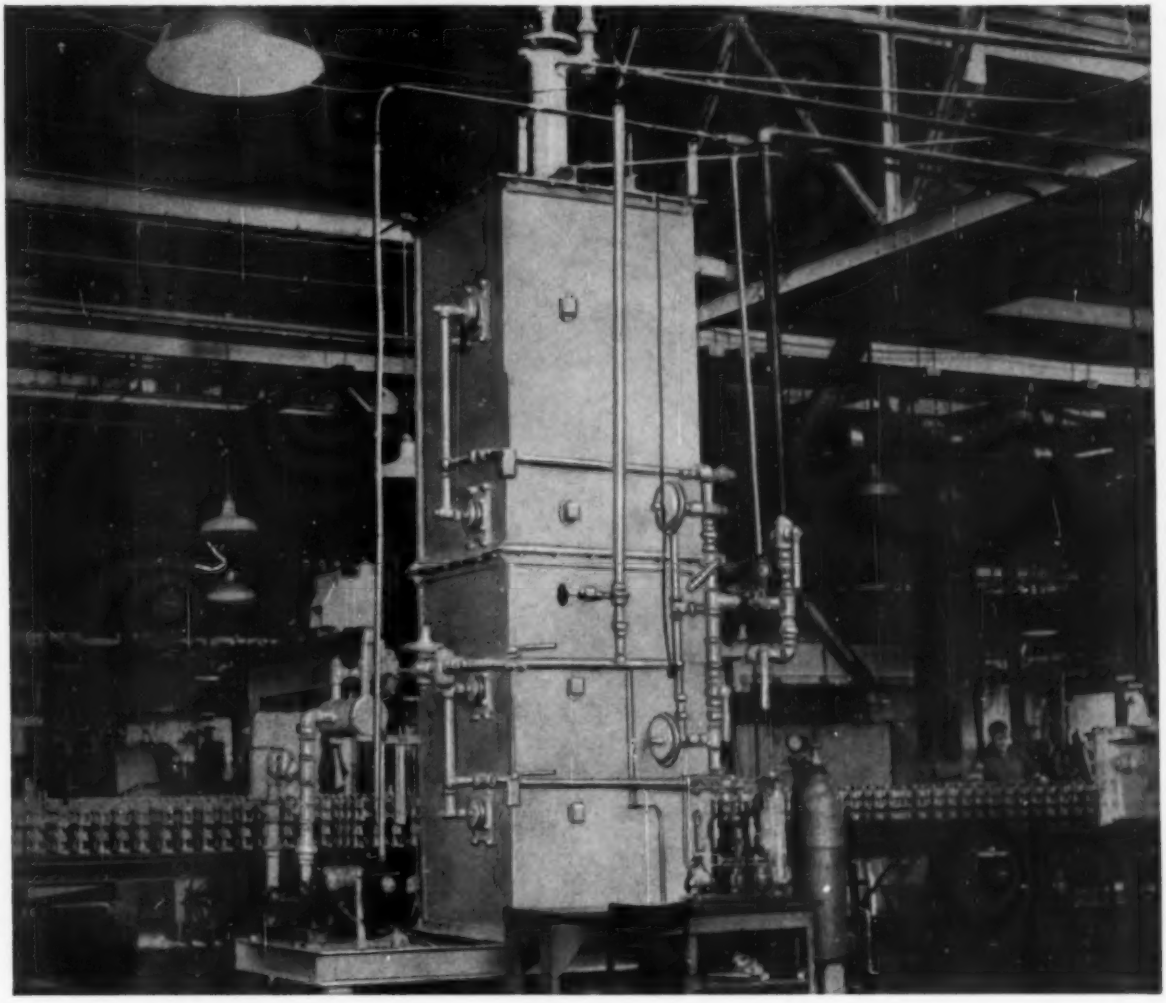

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The heat treating of malleable iron parts involves quenching in water or brine with subsequent tempering. Quenching in oil is reserved for components of critical configuration. The uniformity of temper carbon distribution is the most important criterion of a successful treatment.

Factors influencing the heating cycle are wall thickness and size of the casting, rate of diffusion of carbon in the matrix, density of the charge in a furnace, desired mechanical properties in the end product, and maximum temperature attained.

Silicon is of maximum importance in determining the rate of carbide decomposition. Manganese is next with respect to the structural characteristics of the end product. Excessive amounts of phosphorus and sulphur cause hot tears and will lower mechanical properties.

Wear tests showed that, surprisingly, a malleable iron part, hardened to about Brinell 400 would outlast a 0.60% carbon steel containing 1% manganese by almost three to one. Brake drums present an interesting application of heat treated malleable iron, where a uniform coefficient of friction and good heat conductivity are required.

Welding of malleable iron has proved to be successful if certain precautions are observed: Phosphorus and sulphur contents must be held below 0.05% and manganese should not exceed 0.25%.

Initial fears that the development of nodular iron might prove the undoing of malleable iron proved groundless; on the contrary, this competitor has stimulated increased research and advanced malleable iron metallurgy.

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Casting Titanium and Zirconium

Digest of "Titanium and Zirconium Casting Developments by the U.S. Bureau of Mines", by A. H. Roberson, *Journal* of the Institute of Metals, Vol. 86, September 1957, p. 1-6.

DESPITE the rapid development of equipment for other processing methods, comparatively few articles have discussed the feasibility of casting titanium and zirconium. These metals necessitate special foundry practices because of their high melting points and their capacity for reacting with ordinary refractories. The Albany, Ore., laboratory of the U.S. Bureau of Mines, however, has successfully produced uncontaminated castings of both titanium and zirconium, weighing up to 75 lb.

Consumable electrode-type furnaces with water cooled copper crucibles are recommended to avoid contamination. Both bottom-pouring and tilting furnaces are satisfactory but the latter type is preferable. It avoids tapping difficulties. With either furnace, the trick is to melt fast enough to maintain a large pool of molten metal. The 10-in. diameter melt has a 15-in. deep pool. Characteristically, a skull forms on the crucible during melting. It usually amounts to 10 or 25% of the furnace volume. Smaller furnaces give better yields. By using the skull remaining from a previous run, recoveries range up to 90% of electrode burn-

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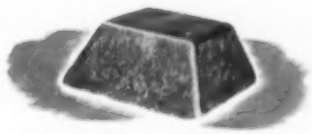

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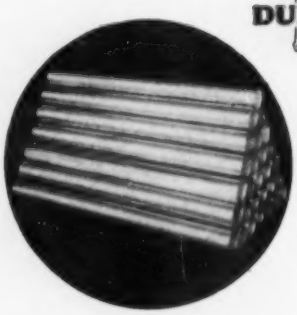

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Casting . . .

off weights. Skulls may be reused up to 10 times before becoming too thick. Scrap can be charged on the skull before melting in amounts up to 10% of the final melt weight.

The amount of metal available for casting depends on the melting rate; the rate ordinarily increases as the furnace pressure decreases. Roberson found that the maximum melting rate is obtained at a pressure slightly higher than that at which the glow discharge occurs. The optimum pressure is higher than the vapor pressure of the molten metal but can not be specified because of difficulties in measurement. In the Albany furnaces, optimum melting rates were obtained at pressures of about 30 mm. of mercury. At that pressure, 16 lb. of zirconium or 11.5 lb. of titanium could be melted per minute in an 8-in. furnace using 9000 amp. at 30 v. Like other metals, titanium and zirconium must be superheated to develop sufficient fluidity for casting. Titanium cast at 4170° F. as measured by an optical pyrometer ran 27 in. when cast in a ½-in. square fluidity-spiral mold made of graphite.

In operating the melting-casting furnaces, a cathode large enough to supply metal for the casting is suspended from the electrode holder. The consumable electrodes are alloyed if necessary to produce the desired composition. They are made by pressing sponge or chips or by welding together pieces of massive metal. After the furnace is closed, it is evacuated to a pressure of about 100 μ, then backfilled with a mixture of helium and argon, then pumped down to the optimum pressure for the desired melting rate. With the tilting furnace, the first casting takes 1 hr.; subsequent castings about 25 min.

Conventional mold materials are not satisfactory for titanium or zirconium but zirconium silicate can be used for thin, light castings. Rammed or machined graphite molds are considered suitable but cause some carbon contamination on the skin. Copper and aluminum molds work well if they are designed to have enough heat capacity. Additional study will provide data on proper venting, grating and risering practices.

F. W. BOULGER

Metal Progress

Bulletin Board...

The Buyers Guide For Metals Engineers

the GRIES

MICRO-REFLEX

HARDNESS TESTER

Loads: 10 to 3000 gram with CARL ZEISS Optical System

Measurement: to 0.0001 mm. . . . Observations on Ground Glass . . . Projection: to 0.001 mm. . . . Many Unique, Very Important Features.

INVESTIGATE!

Write for Bulletin No. A-16

GRIES INDUSTRIES, INC.
Testing Machines Division
NEW ROCHELLE 3, N.Y.

LIST NO. 135 ON INFO-COUPON PAGE 169

METAL POWDER PARTS / UNUSUAL SHAPES

carburized tensile strength to 200,000 psi.

Supermet specializes in powder metal parts requiring extreme physical properties and/or unusual intricacy. Controlled carburized case plus new approaches to die design bring you steel parts with the economy of powder metallurgy. In electrolytic iron, 7 ranges of properties are available; ask also about stainless steel parts. As an indication of capability, a counter pinion (*) is currently produced with tooth extensions which withstand a 60 lb. load. Previously the part could only be made by machining; now it is fabricated at a 25% saving by the Supermet process. Send your part print today.

SUPERMET DIVISION

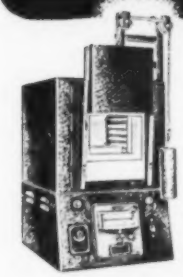
GLOBE INDUSTRIES, INC.

1467 Cincinnati St., Dayton 8, Ohio

free technical literature

LIST NO. 174 ON INFO-COUPON PAGE 169

HUPPERT ELECTRIC FURNACES AND OVENS
for Laboratory and Plant



*For 2300°F. add $95.00 to No. 11 and No. 12, and $105.00 to No. 12A. No. 12A can be furnished for 3 phase at no additional cost. For floor model add $52.00 to above prices. No. 869 standardly supplied for 2200°F.

BENCH MODELS

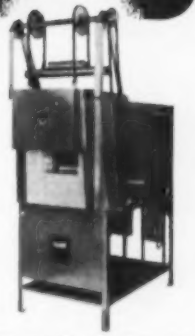
- Range: 300°F. to 2000°F.
- High temperature, heavy-duty Kanthal elements
- Multi-insulation
- Counter-weighted, tight-sealing door
- Operational pilot light
- Shipped ready to operate

Model No.	Inside Dimensions			KW	Prices 220 Volt Single Phase	
	Wide	High	Deep		With Huppert Input Controller	With Electronic Prop Controller
869	8"	6"	9"	4	$296.00	$480.00
11*	8"	6"	12"	4	306.00	518.00
12*	8"	8"	12"	6	382.00	590.00
12A*	8"	8"	18"	9	490.00	698.00

FLOOR MODELS
28 Standard Sizes

- Continuous operation to 1850°F.—intermittent to 1950°F.—for 2300°F. on special order.
- Complete with automatic electronic controller.
- Tight-sealing, wedge-type door.
- Multi-insulation for maximum efficiency.

Shipped Ready to Operate
Model No. 16 Illustrated $1050.00



Also Special Models for Specific Requirements. Special KR-Supers to 3100°F.

K. H. HUPPERT CO.
Manufacturers of Electric Furnaces and Ovens For A Quarter Century
6844 Cottage Grove Ave., Chicago 37, Illinois

Request new catalog on furnaces, ovens, data, prices.

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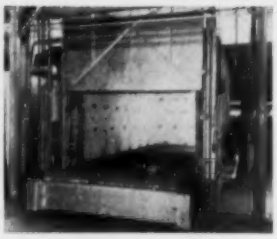
PACIFIC FURNACES ARE ENGINEERED FROM THE INSIDE OUT



The special wall holding anchor tiles developed and patented by Pacific have solved the problems of furnace wall failures due to unequal expansion and contraction of inner and outer wall surfaces. These wall holding anchor tiles save rebuilding time, costs and are GUARANTEED FOR FIVE YEARS.

Pacific ENGINEERS. . . . BUILDS . . . SERVICES all types of industrial heating equipment.

FOR COMPLETE INFORMATION ON OUR SERVICES —WRITE OR CALL

THE Pacific INDUSTRIAL FURNACE CO.

24680 Telegraph Road, Detroit 41, Michigan
Phone: Kenwood 7-4250

LIST NO. 173 ON INFO-COUPON PAGE 169

How to Cut Pot Costs:

Buy low-cost Eclipse pressed (not welded) steel pots . . . and replace them on a regular schedule.

1 Lower initial cost
2 Elimination of failures
3 Faster, more even heating
4 Quantity discounts earned on your total purchases in any 12 month period.

Guaranteed free from defects. Write:
Eclipse Fuel Engineering Company
Industrial Combustion Division
1127 Buchanan St., Rockford, Ill.

Eclipse PRESSED STEEL POTS

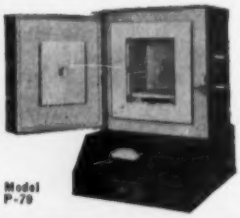
LIST NO. 176 ON INFO-COUPON PAGE 169

PRODUCED AND PRICED RIGHT FOR YOUR ELECTRIC FURNACE NEEDS

DYNA-TROL

MODEL NO.	FIRING CHAMBER (H.W.D.)	PRICE (300° to 2000°)	PRICE (400° to 2300°)
P46	4½"x4½"x9"	$90.00	$110.00
P79	8"x8"x9"	$205.00	$225.00
P818	8"x9"x18"	$480.00	$528.00
P414	14"x14"x14"	$525.00	$603.25
P124	12"x12"x24"	$715.00	$822.25
P818	18"x18"x18"	$775.00	$887.50
P136	18"x18"x36"	$1125.00	$1312.00

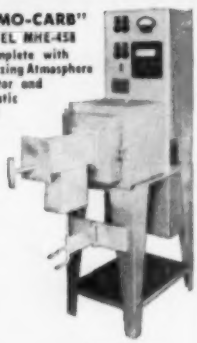
Automatic Controls Available on all Models



Model P-79

- Infinite zone temperature control
- Zone temperature indication by Pyrometer Selector Switch
- Automatic hold and cut-off instrument available
- Patented element holders
- Infinite variety of time-temperature curves obtainable
- Rugged construction

"ATMO-CARB"
MODEL MHE-458
Complete with Carburizing Atmosphere Generator and Automatic Control



$1325.00
Other Sizes and Arrangements Available

L&L MANUFACTURING CO.
Chester 77, Pa.

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An ASM book of interest to both the expert and the student. The exciting story of the progress of metals. What metals mean to man.

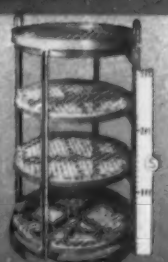
$2.95

Order your copy from ASM Headquarters in Cleveland. Postage paid.

choose from the most complete line OF BASKETS, TRAYS, FIXTURES, RETORTS, CARBURIZING BOXES, POTS.

COR-WAL RETORT

Through serving commercial heat treaters and heat treating departments all over the U.S. for many years Stanwood has developed the most complete line of heat treating equipment. We can make fast delivery with maximum economy. If you require a special container, fixture or furnace part for which we do not have patterns our engineers can quickly develop and submit a design to meet your requirements. Send for catalog.
Sales Representatives in Principal Cities.



STANWOOD FIXTURE

HEAT TREATING EQUIPMENT

STANWOOD CORPORATION
4837 W. CORTLAND STREET • CHICAGO 39, ILL.

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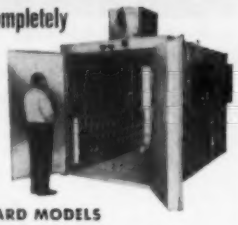
GRIEVE-HENDRY
WALK-IN OVENS

Shipped Completely "Set - Up"

Previously Tested and ready to operate.



6 STANDARD MODELS

No engineering charges

Latest convenience features and safety devices included. Design changes to suit requirements. Electric, gas or oil heated. Write for bulletin.

87 Standard Bench and Cabinet Models $110.50 and up

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TAKING A BEATING

500 lb. loads, 12 hrs. a day, 5 days a week at 1600° F. temps. raise havoc with ordinary containers at BASSICK'S Bridgeport plant.

But since changing to WIRETEX BASKETS, life span is three times greater . . . heat temps. extended . . . corrosion ended . . . loads distributed, handled better and faster. Free flow of quenching oil is assured; secondary handling eliminated. BASSICK engineers report increased production, improved quality control, greater savings.
If better heat treating is your problem . . . Call Wiretex. Send for literature.

Specialists in Processing Carriers Since 1932.

Wiretex mfg. co., 5 Mason Street, Bridgeport 5, Conn.

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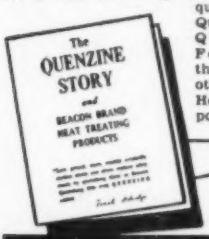
FREE
the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .



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ALDRIDGE INDUSTRIAL OILS, Inc.
8401 W. 140th St., Cleveland 11, Ohio

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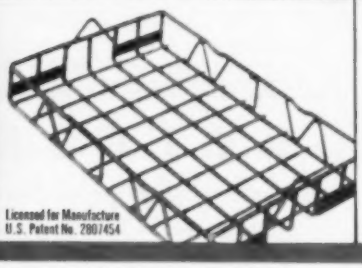
ALLOY ENGINEERED RETORTS & BASKETS

Engineering answers and highest quality manufacturing . . . developed by years of alloy specialization.



Licensed for Manufacture U.S. Patent No. 2803454

Designers . . . Engineers . . . Fabricators . . . Call Alloy for quick service on all your heat treating requirements.

ALLOY ENGINEERING CO.

74 SHELDON ROAD
BEREA, OHIO

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Regulate and control electric ovens and furnaces better, accurately, and efficiently, with SORGEL Saturable Reactors

Saturable Reactor with tap changing transformer

Any amount of A.C. power from 1 Kva to 3000 Kva, single phase or 3-phase, at any voltage, can be controlled, regulated, and varied in stepless increments, with SORGEL Saturable Reactors.

The control can be a small manually operated hand wheel that can be placed in any desired location, or it can be automatically controlled, regulated and varied by a thermostat or any other instrument or device.

SORGEL reactors are designed to meet your exact requirements. Let us know what your problems and requirements are, and we will submit our recommendations with complete information.

Write for Bulletin 658.

Also a complete line of dry-type transformers.

All standard and intermediate ratings, ¼ Kva to 10,000 Kva, 120 to 15,000 volts.

Sales Engineers in principal cities

Consult the classified section of your telephone directory, under the heading "Transformers," or communicate with our factory.

SORGEL ELECTRIC CO., 834 W. National Ave., Milwaukee 4, Wis.

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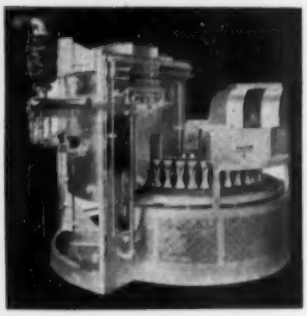
GOOD USED EQUIPMENT AT REAL SAVINGS TO YOU!

LIKE-NEW SELAS ROTARY-HEARTH HIGH-TEMPERATURE GRADIATION FURNACE!



Hearth diameter, 7 ft.
Door opening, 8 in. wide by 22 in. high
Gas fired for 2400° F. Complete.
Also:

- Globar box furnaces, 12 in. wide by 18 in. long by 8 in. high
- Tempering box furnaces, 43 in. wide by 42 in. long by 30 in. high
- Carbonitriding furnaces, 24 in. wide by 36 in. long by 18 in. high
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- Brazing roller hearth, 24 in. wide by 20 ft. long by 11 in. high
- Annealing roller hearth, 49 in. wide by 34 ft. long by 12 in. high

Wire or call for our complete list of used heat treating and plating equipment.

METAL TREATING EQUIPMENT EXCHANGE, INC.
9825 GREELEY ROAD
DETROIT 11, MICHIGAN

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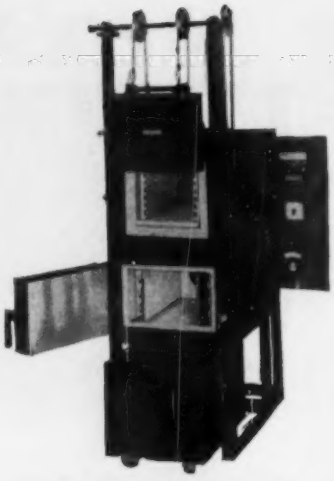

SAVE SPACE WITH A

SERIES 8055

COMBINATION MODEL

The Series 8055 is two electric heat treating furnaces (hardening 2000 and 2300° F., and drawing 800 and 1250° F.) in the floor space of one furnace. Each furnace is independently controlled permitting hardening and drawing operations to be performed at the same time. All models are delivered with separate controls for each furnace. The 8055 series is made in nine standard sizes . . . other models are made to your specifications. Furnaces operate on standard line voltage . . . no transformer necessary. A hardening and preheating combination is also available.

Write for a free catalog of the entire Lucifer line. Engineering advice is offered without obligation. Write, wire or call . . .

LUCIFER FURNACES, INC.
NESHAMINY 7, PENNA.
Phone: Diamond 3-0411

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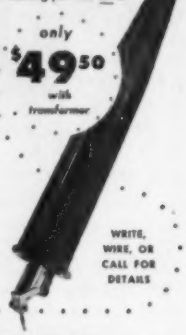
ARC ETCH ANY METAL OF ANY HARDNESS—*Quickly—Easily*
WITH THE
ACTOGRAP PEN

Only the ACTOGRAP metal etching pen has all of these features:

- Freedom from mechanical vibration
- Short, powerful, continuous arc—will etch hardest metals rapidly
- Does not heat up
- Light and small—can be used like a fountain pen
- Operates optionally on battery or conventional AC current
- Depth of etch can be regulated by an exclusive selection switch

only **$49.50** with transformer



WRITE, WIRE, OR CALL FOR DETAILS

NEWAGE INDUSTRIES, INC.
222 York Road
TUmer 4-8494
Jenkintown, Pa.

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ULTRASONIC CLEANING EQUIPMENT by a COUSTICA ASSOCIATES, INC.

***PAID FOR ITSELF QUICKLY**

Otis engineers report that the Acoustica DR400 Ultrasonic cleaning unit **"paid for itself in the first six months operation... reduction of hand labor operations... resulted in a savings in the ultimate manufacturing costs."**

Photographed at Otis Elevator Company, Electronic Division

The electronic chassis frames and sub-assemblies are immersed and cleaned of excess solder and solder flux in a fraction of the time previously required.

Write for "Building Blocks for Industry"

*LETTER ON FILE.

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Plan now to attend the 41st National Metal Congress and Exposition in Chicago, November 2 to 6.

Look ahead . . . you'll want to participate in this regular Metal Show that has the metal industry's stamp of approval . . . always successful for the exhibitor! Plan to take part . . . don't wait!

Floor plans and descriptive literature can be obtained by writing to ASM Headquarters in Cleveland. 7301 Euclid Avenue.

Need Help Designing That Aluminum Extrusion?

TEAM UP with JARL

THERE'S A WORLD OF DIFFERENCE

The *difference* starts the moment you meet the Jarl salesman. He's an engineer . . . well qualified to make on-the-spot recommendations in designs. Team up with Jarl and you'll get the right shapes made to most exacting design specifications. You'll be sure of close die control . . . quality safeguards every step . . . on-time deliveries. Send for our stock die catalog or send rough sketches for assistance with your design.

ANODIZING

JARL EXTRUSIONS, INC.
Dept. MP, Linden Ave. • East Rochester, N. Y.

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A NEW PRODUCT IS PLANNED

. . . and you have an idea that *one special* extruded aluminum shape can be used instead of *several standard* rolled sections of another metal, saving many manufacturing steps and money. The idea needs exploring . . . the opinion of experts. But, the budget for research of this type is slightly battered. The matter is no longer a problem, for G.E.I.'s highly skilled staff is eager and ready to discuss your idea with you, *at no obligation*, on one part or a million. G.E.I. engineers specialize in adapting extruded aluminum to new functional roles . . . and they can soon tell you whether your idea is fact or fancy.

GENERAL EXTRUSIONS, INC.
4040 LAKE PARK RD., YOUNGSTOWN, OHIO
Mill Representatives at St. Louis, Detroit, Memphis and Cincinnati
Consult your classified phone book under Aluminum Products.

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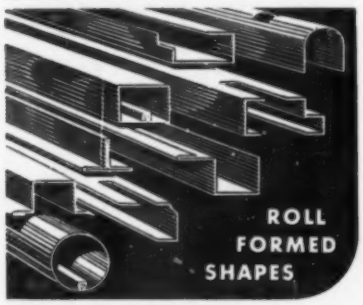

Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or nonferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

MAIN OFFICE AND PLANT
3761 OAKWOOD AVE. • YOUNGSTOWN, OHIO

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Sel-Rex®

PRECIOUS METALS FOR INDUSTRIAL PLATING

BRIGHT GOLD
Mirror-bright finish in any thickness directly from the bath. **Patented**

PUR-A-SALTS
Restores contaminated cyanide plating baths to full, trouble-free operation. **Patented**

SILVREX BRIGHT SILVER
Crystal-clear solution that produces mirror-bright deposits. **Patented**

SILVER SOL-U-SALT
Non-dusting—safest and easiest to use.

BRIGHT RHODIUM
Brilliant, fine-grained non-tarnishing deposits.

RHODEX
Only rhodium electroplating process that yields extra heavy compressively stressed deposits. **Patent Pending**

ACID GOLD PLATING PROCESS
Developed specifically for plating printed circuits. Mildly acid so that neither the laminate nor the adhesive at the inter-face of printed circuit boards are affected during the plating process.

Complete installation and servicing on all precious metals processes.

SEL-REX CORPORATION

Dept. BB, Nutley 10, New Jersey

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Top Uniform Accuracy Over-All Visibility at Lower Cost!

★ SALT FOG
★ CORRODKOTE
★ HUMIDITY TESTS

Get the best from every test with

G.S. Corrosion Test Cabinets

Designed to meet A.S.T.M. and Gov't Specifications. Many new, exclusive, features. All-welded H-T Lucite, lined Steel or lined Stainless—sizes, types to suit. Send for details, prices.

The G. S. Equipment Co.
15585 Brookpark Rd. Cleveland, Ohio
Phone: CL 2-4770

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- **CLAMPS, JAWS & BASE PLATE ARE ELIMINATED**
- **NO CONVERSIONS OR CALCULATIONS**
- **TEST ANY SIZE, SHAPE OR TYPE METAL**
- **NO SKILL REQUIRED**
- **SCALE READINGS IN ROCKWELL & BRINELL**
- **ACCURACY GUARANTEED**

Many thousands used by industry and government. Write, wire or call for additional details and prices.

NEWAGE INDUSTRIES, INC.
222 York Road *Jenkintown, Pennsylvania*
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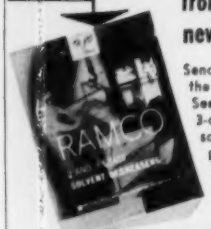
Q A METAL PARTS CLEANING PROBLEMS?

Get the answers RIGHT from RAMCO'S new BULLETIN!



Send for your copy of the Ramco Bulletin. See how Ramco 2- and 3-dip degreasers can solve your metal parts cleaning problems, economically, efficiently, safely! Write today!

RAMCO EQUIPMENT CORP.
DIV. OF RANDALL MFG. CO., INC.
809 Edgewater Rd., New York 39, N.Y.

LIST NO. 128 ON INFO-COUPON PAGE 169

FIND CRACKS QUICK!

Use Spotcheck
"SPRAY-ON"
Dye Penetrant Inspection

QUICK TEST ENDS VISUAL GUESSWORK!

SPOTCHECK finds cracks, porosity, and leaks you can't see (any defect open to the surface). SPOTCHECK—marks them with a brilliant red warning. Users report speedy, money-saving results. SPOTCHECK is used to inspect metals, carbides, ceramics, plastics, etc. Multi-use SPOTCHECK can simplify your maintenance and in-progress inspections. SPOTCHECK'S complete SK-3 kit is portable; no other equipment needed!

Spotcheck offers

- NEW! NONFLAMMABLE
- PUSH-BUTTON EASE
- FLEXIBILITY . . . Use on tools, parts, machinery, etc.
- LOWEST COST Dye Penetrant materials — pressure canned or bulk. Why use higher priced substitutes?

COMPLETE SK-3 KIT ONLY
$36.00 U.S.A. only
Plus $1 for packing and shipping

CALL YOUR DISTRIBUTOR or Mail Check or P. O. with Coupon Today!

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☐ Please send ____ SK-3 kits @ $36.00 each plus $1.00 each packing and shipping.
☐ Send FREE bulletin only. Includes low SPOTCHECK material prices.

Name _____ Title _____
Company _____
Address _____
City _____ Zone ____ State _____

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Specify TECHNIC HG for all the attributes of HARD BRIGHT GOLD

TECHNIC HG GOLD delivers *all* the hard bright gold characteristics you need for electronics applications, decorative finishes, etc. Deposits may be controlled to any thickness, duplicated with scientific precision.

Attributes include: Bright smooth-grained deposits; super hardness (130-150 DPH); low stress, less porosity than conventional bright gold; high karat (23 +). Other advantages include: Wide operating range (60° to 95°F), no cooling or heating required; low cyanide, less than 1/10 oz. per gallon; no organic brighteners; low cost, less than 10¢ per troy oz. over regular 24 kt. gold. Brochure is available: "Technic HG Gold."

TECHNIC ENGINEERING

Technic engineers consult on exploratory projects and collaborate in problem solving. They design and install your precision metal electroplating equipment, or re-design and modernize existing installations—*and they stand by until optimum performance is assured.*

TECHNIC BIBLIOGRAPHY

"Electroplated Gold"; "Precious Metal Electroplating Data: Gold, Rhodium, Palladium, Platinum"; "Electroplated Platinum"; "Electroplated Palladium"; "Electroplated Rhodium"; "Analysis of Gold & Gold Alloy Solutions."

Phone, wire, TWX or write — consult us without obligation. Ask for Technic publications in your area of interest.

623-8

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39 Snow Street
Providence, R. I.
JAckson 1-4200
Chicago Office
7001 North Clark St.
THE WORLD'S BEST SOLUBLE PRECIOUS METALS FOR ELECTROPLATING

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Leitz MINILOAD TESTER
FOR VICKERS AND KNOOP HARDNESS

STANDARD HARDNESS TESTERS for ROCKWELL and BRINELL TESTS also available.

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OPTO-METRIC TOOLS, INC.
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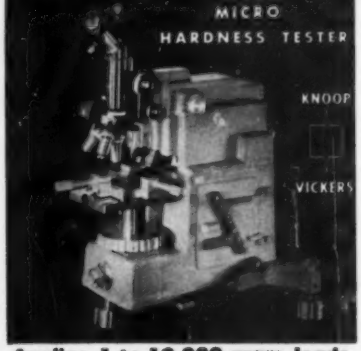
KENTRON
MICRO HARDNESS TESTER



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TensilkuT machines a wide range of metals including steel, aluminium, stainless steel, copper, titanium, uranium, lead, the super alloys and all plastic materials.

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Trade Mark Registered U.S. Patent Office Patents Pending United States & Canada.

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INCORPORATED
Danbury Industrial Park • Danbury, Conn.

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Portable and Precise HARDNESS TESTER

Model ST-5

- **Weight: 7 oz.**
- **Length: 6¾ in.**

Direct scale readings in Rockwell and Brinell. Make hardness tests anywhere in seconds. Ideal for testing specimens too large for standard testing equipment. Saves time and labor moving heavy pieces to a bench-tester. Quickly calibrated. Easy to read. Used by many large industries. Accessory equipment includes test stand and carrying case.

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HARDNESS TESTING SHORE SCLEROSCOPE

Pioneer American Standard Since 1907

Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

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Solve Inspection Sorting Demagnetizing Problems with MAGNETIC ANALYSIS...

MULTI-METHOD EQUIPMENT

Electronic equipment for non-destructive production inspection of steel bars, wire rod, and tubing. Detects mechanical faults and variations in composition and physical properties. Average inspection speed – 120 ft. per minute.

SPECIAL EQUIPMENT

Electronic equipment for non-destructive production inspection of non-ferrous bars and tubing . . . as well as both non-magnetic stainless and high temperature steel bars and tubing – seamless or welded. Mechanical faults, variations in composition and physical properties are detected simultaneously. Average inspection speed – 200 ft. per minute.

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Electronic instruments for production sorting of both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

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Electrical equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

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Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

"THE TEST TELLS"
For Details Write:
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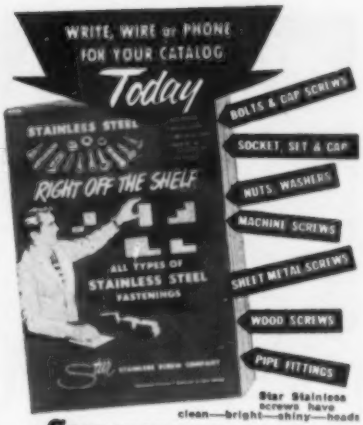

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CORROSION RESISTANT

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THE NEW DERMITRON NON-DESTRUCTIVE COATING THICKNESS TESTER

FAST... ACCURATE NON-DESTRUCTIVE DIRECT-READING

- **Instantly measures the thickness of metallic and non-metallic coatings and films**
- **Based on eddy-current principles**
- **Enables measurements on small or otherwise inaccessible areas**

This portable instrument for both laboratory and production use, gives fast, accurate and direct readings of virtually any coating on any base, including:

- **Metal coatings (such as plating) on metal base (magnetic and non-magnetic)**
- **Non-metallic coatings (such as paint, anodizing, hard-coat, ceramic) on metal base**
- **Metal films (such as vacuum metalizing) on non-metallic base (plastics, ceramics)**

Write for latest bulletins and questionnaire to help solve your thickness testing problems

UNIT PROCESS ASSEMBLIES, INC. UPA

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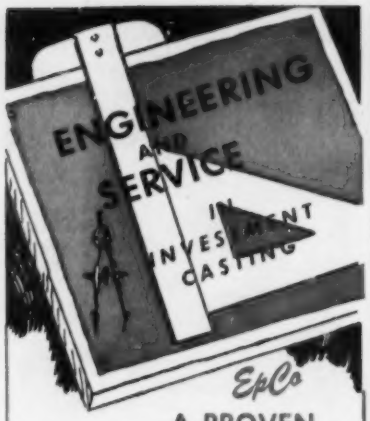

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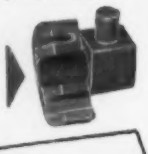
INVAR CASTING Special Feature — Nickel content held to 35% minimum — 36% maximum

STAINLESS STEEL PART for milk bottling unit formerly machined from solid stock. Only finish operations required are reaming small dia. of counterbored hole and drilling and tapping for set screw.



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Specialists in All Phases of METAL CLEANING EQUIPMENT

- DEGREASERS • AGITATING WASHERS • PICKLERS
- PHOSPHATIZING WASHERS • ALKALINE WASHERS
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We will be happy to send a sales engineer to help you with any metal cleaning equipment problem. Complete information on request.

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CIRCO EQUIPMENT COMPANY

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Inspect NON-FERROUS - NON-MAGNETIC Metals . . .

with Magnetic Analysis MULTI-FREQUENCY EQUIPMENT. An eddy current tester with six inspection methods operating simultaneously — for high-speed, non-destructive testing of non-ferrous and non-magnetic tubing, bars and wire from ⅛" to 3" diameter. Detects both surface and sub-surface flaws, and variations in chemical, physical and metallurgical properties at speeds of 200 to 600 ft./min.

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RUST-LICK IN AQUEOUS SYSTEMS

Eliminates RUST & Fire Hazards Non-Flammable Non-Toxic

Send for Brochure: The ABC of Rust-Lick for Rust Prevention

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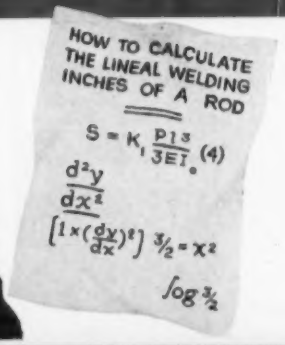
ASK WHITEY ABOUT WELDING STAINLESS



Whitey says: "It takes a genius to count the cost beforehand—especially if he's only half familiar with his tools (but then he's no genius) . . . You can't guarantee a rod to weld any predetermined length of stainless without knowing the operator's technique, the type of joint, the fit—but, by knowing the make and quality of the rod you can be a bit psychic in your estimate."

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Stainless and Heat Resistant Arc Welding Electrodes of all analyses . . . coated, straightened . . . cut . . . coiled and spooled.

MAURATH, INC. 21830 Miles Avenue • North Randall 22, Ohio
Phone: MOntrose 2-6100

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SPECIAL SERVICE ON *HIGH SPEED* STEEL FORGINGS

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28 Years Of Specialized Experience
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Expert High Speed Steel Blacksmiths

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your comprehensive independent mill source of magnesium alloy . .

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AZ51
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AZ81
ZK60
ZK30
M-1
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SOLID SHAPES .022" min. to 8½" circle
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Standby Gas Plants for Industrial Gas Users

Anhydrous Ammonia Bulk Tank Installations

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LET US DESIGN AND INSTALL YOUR COMPLETE PLANT

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for
- shrink fits
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1.5 and 6.5 cu. ft. capacities. Sturdy, all-steel cabinet construction. Sublids for constant inside temperature. Adjustable temperature controls. Special accessories available.

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Deerfield, Michigan
Specialists in Trend-Setting Refrigeration

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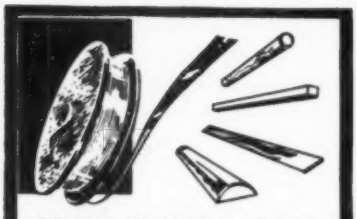

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Beryllium Copper • Bronzes
Other Non-ferrous Alloys
Rounded or square edges.
Available with hot-tinned finish for solderability.
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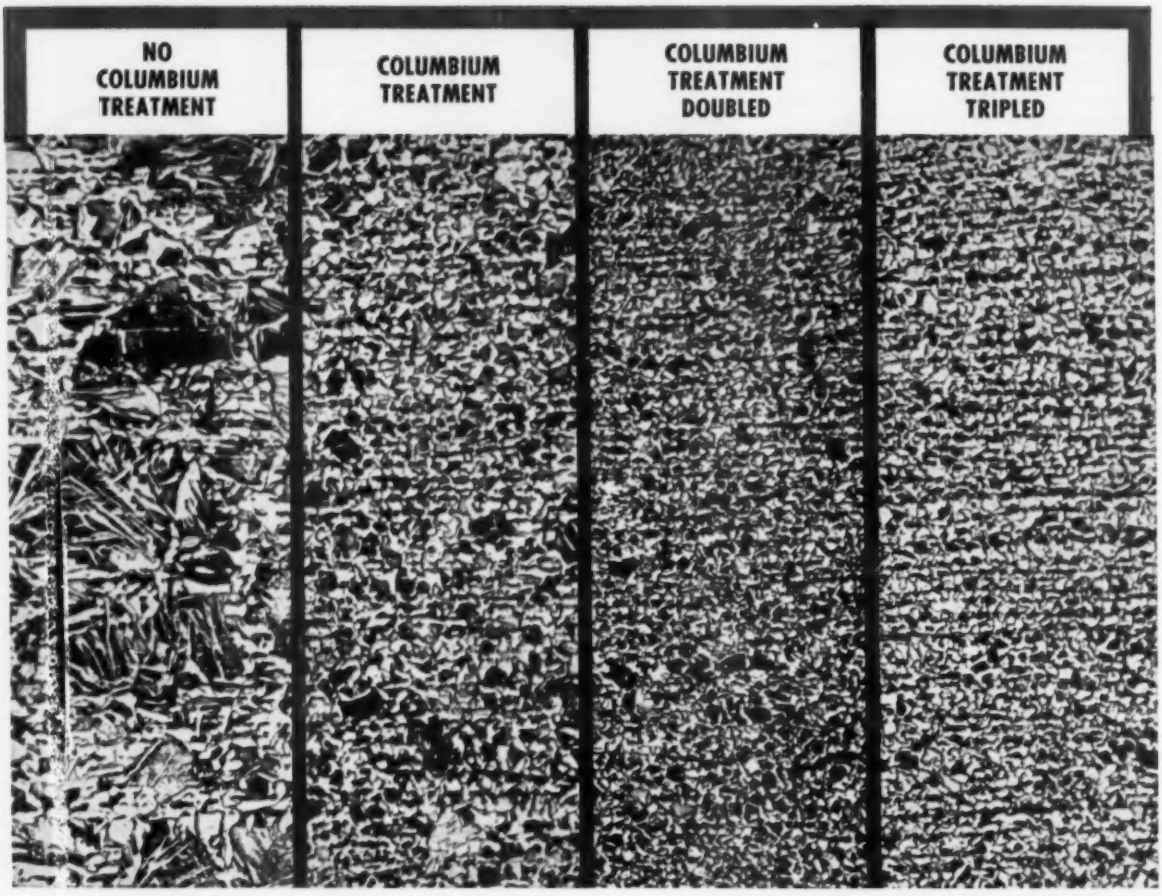
HOW GREAT LAKES



Composite of photomicrographs made from the same heat of mild carbon steel shows the effect of varying columbium treatments on the grain structure of the steel.

The Great Lakes Family of High-Strength Steels

N·A·X FINEGRAIN STEEL

Lets you design superior performance, longer life and less weight into your product. Many diversified applications.

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Offers all the characteristic features of N-A-X Finegrain, plus greatly enhanced resistance to atmospheric corrosion.

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Quenched and tempered steels of excellent weldability and toughness, with yield strengths from 75,000 - 110,000 psi.

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STEEL CORPORATION'S NEW GLX-W STEELS GIVE ... HIGH STRENGTH TOUGHNESS REDUCED COSTS

Key to the success of Great Lakes' new GLX-W Series of steels is the fine grained internal structure produced by treatment with columbium. This grain refinement also contributes to ductility. And in addition, the GLX-W Series' low carbon and manganese content assures excellent weldability with freedom from underbead cracking under all conditions.

COST AND WEIGHT SAVINGS

Where design permits the replacement of carbon steel with GLX-W steels, weight savings of 20 to 35 per cent, and cost savings of 10 to 25 per cent can be realized. When replacing alloy steels the cost savings can range from 25 to 35 per cent. These steels feature higher yield strengths, greater tensile strengths and increased toughness without costly heat treatments or extensive alloy additions.

The GLX-W Series is so priced that substantial cost reductions can be obtained by weight reduction over mild carbon steel. Cost reduction can also be obtained over alloy steels because of the lower price of GLX-W steels.

MANY USES FOR GLX-W STEELS

GLX-W steels are especially recommended for a broad range of applications in mobile equipment and pressure vessels, as well as the transportation and construction fields.

STRONGER AND TOUGHER

GLX-W steels are stronger and tougher than ordinary mild carbon steels and in some applications can do the job now being done by the more costly alloy steels.

GLX
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For additional technical information about these economical GLX-W steels write

Product Development Division, Dept. B-1
GREAT LAKES STEEL CORPORATION
Detroit 29, Michigan • Division of
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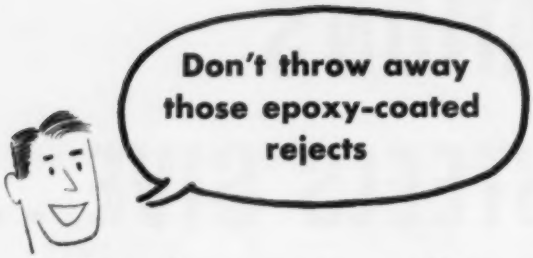

Here's a new paint stripper that will save them

Do you scrap perfect metal parts that have been imperfectly coated with epoxies, vinyls, polyesters and other hard-to-strip paints or lacquers?

In the last few months, users of Oakite Stripper S-A have eliminated many such losses. Here's what some of them say about it:

CALIFORNIA: An aircraft manufacturer tested many strippers on an epoxy designed to resist attack by hydraulic fluid. Finally found that Oakite Stripper S-A is "the only one that safely strips this paint from anodized aluminum."

NEW YORK: A camera maker coats flash bulb reflectors with black vinyl paint outside and aluminum paint inside. "Stripper S-A is the fastest ever used on our rejects."

OHIO: A maker of toy pistols had trouble stripping alternate coats of lacquer and metallized aluminum. Now "Stripper S-A does it amazingly fast and remetallizing is completely satisfactory."

CALIFORNIA: A producer of metal furniture uses Stripper S-A to remove clear epoxy from plated parts. Chemist says "This is the best stripper on the market."

ALABAMA: A hardware maker had trouble stripping lacquer from brass door knobs. Oakite Stripper S-A now does the work in "less than ⅓ the time taken by any other stripper."

NEW YORK: A manufacturer of business machines tested several strippers on various finishes on steel and aluminum. Verdict in favor of Stripper S-A was: "It's doing a wonderful job."

CONNECTICUT: A maker of brass lipstick shells has found that "Stripper S-A quickly strips epoxy lacquers from rejects and heavily coated work spindles."

CALIFORNIA: A missile maker reports that "Stripper S-A is doing a fine job stripping vinyl from stainless steel and titanium."

FREE Write Oakite Products, Inc., 26H Rector St., New York 6, N. Y., for complete information on Oakite Stripper S-A.

OAKITE

SCIENCE

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Technical Service Representatives in Principal Cities of U. S. and Canada
Export Division Cable Address: Oakite

Foundry Activities in Scandinavia

Digest of "The Foundry Industry in Sweden", by Lars Villner; "The Foundry Industry in Denmark", by Ove Hoff; "The Foundry Industry in Finland", by O. E. Huhtamo; "The Foundry Industry in Norway", by Torolf Krogvig, *Gjuteriet*, Vol. 47, August 1957, p. 137-156.

IN "The Foundry Industry in Sweden", Lars Villner points out that Sweden is one of those countries whose metal casting in bronze goes back to 1500 B.C. About the end of the Middle Ages, iron casting started, and at the heyday of Sweden's power, she dominated the world market. Many of today's Swedish foundries have their origin in the old iron and steel works.

The export of iron ore was about 17.5 tons in 1955. Sweden produces 1.6 tons of pig iron annually. Their charcoal pig iron has the reputation of being the best pig iron in the world. For the best steel, charcoal pig iron is used with sponge iron.

There are nearly 500 foundries in Sweden, mostly small, and of these 276 are iron, 235 bronze, 166 light metals and 27 are steel foundries. In 1956, these foundries produced 460,000 tons of castings of which 383,000 were iron, 37,000 steel, 19,500 malleable iron, 14,000 brass and bronze, and 6500 light metal castings.

The total of workers in all foundries is about 10,500. Skilled molders are at a premium. In the 57 gray iron foundries investigated, 54 man-hours were required per ton in 1956. Half of all castings are made in the 40 foundries that have been mechanized. Sweden has no oil and the coal is low grade. Hot blast cupolas are used in many instances. Only one or two have basic linings. Basic slags are used in some water cooled, carbon-lined cupolas. Electricity is cheap and as a result both high-frequency and mains-frequency furnaces are common for cast iron, malleable, steel and nonferrous metals. Building requirements demand good insulation and ventilation due to cold winters. The Sveriges Mekanförbund is the over-all trade association and the foundry section has 150 members. The foundries of these

A single ingot shows . . .

how Columbium can improve your steel

Columbium adds some surprising improvements in physical properties to mild-carbon steels. And because of the small amounts required, the extra benefits are obtained at surprisingly little extra cost.

Now, a newly-developed low melting ferro-columbium from MCA enables you to test the effects of columbium in your production *even without the expense of a special melt.* MCA ferro-columbium can be added directly to the mold while your steel is being poured. Result: an ingot identical in size and shape with your regular production run for accurate comparison tests.

MCA has been actively engaged with a number of major steel producers in this development for both open hearth and electric furnace applications and would welcome the opportunity of discussing the matter with your production and engineering personnel.

MOLYBDENUM

Grant Building CORPORATION OF AMERICA **Pittsburgh 19, Pa.**

Offices: Pittsburgh, Chicago, Los Angeles, New York, San Francisco
Sales Representatives: Brumley-Donaldson Co., Los Angeles, San Francisco
Subsidiary: Cleveland-Tungsten, Inc., Cleveland
Plants: Washington, Pa., York, Pa.

MCA

Foundry . . .

members produce two thirds of all castings made in Sweden. The annual budget amounts to $78,000 and 20 persons are employed. The Swedish Iron Masters' Assoc. (Jernkontoret), founded in 1747, includes all the Swedish iron and steel works. The foregoing two associations together with the nonferrous group, sponsor the Swedish Institute for Metal Research, and this employs 40 people. In addition to the foregoing, there is the Assoc. of Swedish Foundrymen which is a society for foundry technique. Total membership is about 900.

The position of "The Foundry Industry in Denmark" is sketched by Ove Hoff. Prior to 1850 there were hardly any foundries, and Denmark was an agricultural community. Now the position is reversed and Denmark has an industry which employs more people than does agriculture. In 1956 the following tonnages were produced: gray and white iron castings 136,000 tons; steel 22,000 tons; malleable castings, mostly blackheart, 1100 tons; and nonferrous 4400 tons. The industry includes 1100 skilled molders, 1100 machine molders, 500 coremakers, 200 apprentices, and 3300 laborers. All coal and oil are imported.

The Institute of Technology in Copenhagen has a chair in foundry technology. The Institute of Danish Foundrymen and the Society of Danish Iron Foundries supervise a school where practical technical education is provided at the foreman level. There is also a foundry laboratory.

In "The Foundry Institute in Finland", O. E. Huhtamo states that the lack of authoritative detailed statistics does not allow the publication of accurate figures of the production and development of the foundry industry. He estimates that 150 foundries, omitting small nonferrous ones, are in operation. The foundries are usually captive, part of large industrial complexes. The yearly output of the iron foundries is 110,000 tons of finished castings. Malleable iron production is about 1850 tons, nodular iron 1300 tons. The ten largest foundries produce 75% of all castings. The production of steel castings is in excess of 12,000 tons, copper alloys 3300 tons, and light alloys 2700 tons. A high degree of mechanization has been achieved in the large foundries.

The State Institute for Technical Reasearch concerns itself with projects having a wide community of interests. There is also an Advisory Committee of Foundries, part of the Assoc. of Finnish Metal and Engineering Industries. A society for foundrymen, the Finnish Foundrymen's Society, provides a meeting ground for all interested.

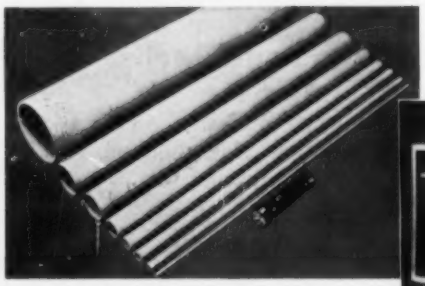
In "The Foundry Industry in Norway", Torolf Krogvig mentions that ironmaking in Norway can be traced back to 500 B.C. Shortly after 1500 A.D., however, a royal decree required that the natural resources of the Norwegian mountains were to be utilized to furnish the king with silver, copper, and iron for his wars in Europe. In 1884 the charcoal blast furnaces were closed as they could not compete with coke.

Electric melting is increasing. The yearly output of pig iron is 55,000 tons, which is mainly vanadium and titanium alloyed high-quality iron. The iron and metal industry as a whole employs 50,000 men of which 5000 work in foundries, and produce 77,000 tons of iron castings, 2200 tons of malleable, 8800 tons of steel, 5500 tons nonferrous, and 1100 tons aluminum. In many instances remote machine shops have their own small foundries. Only two foundries have adopted automation.

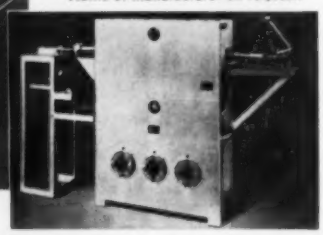
To avoid silicosis, various restrictions have been introduced; for example, shakeout in the molding department is not allowed during working hours, and is done at night. The cleaning is done in a separate room. Washing facilities and medical examination are compulsory. The temperature in the foundry must be above 54° F. The use of olivine in place of quartz sand reduces silicosis hazard. All the steel foundries use olivine exclusively. It has technical advantages with manganese steel and chromium-alloyed materials but has not given the best results with alloyed steel. Many iron foundries also use olivine.

(*Continued on p. 176*)

→McDANEL←



Furnace below equipped with McDanel Zirco Tube, 46" long, 1½" I.D., 1¾" O.D. Operates at temperatures from 1,650 to 3,000° F Name of manufacturer on request.



Protection Tubes Help Produce Controlled Atmosphere at 3,000° F. In Research Electric Furnace

Sintering, brazing and other heat-treating experiments are conducted in this laboratory furnace applied to research. It uses a McDanel Zirco Protection Tube, open at both ends. Sample heats and cools in gas-tight tube, permitting use of many special atmospheres. McDanel Protection Tubes have high resistance to thermal shock—low coefficient of expansion. Special sizes! Write now! *Send for Bulletin P1-55.*

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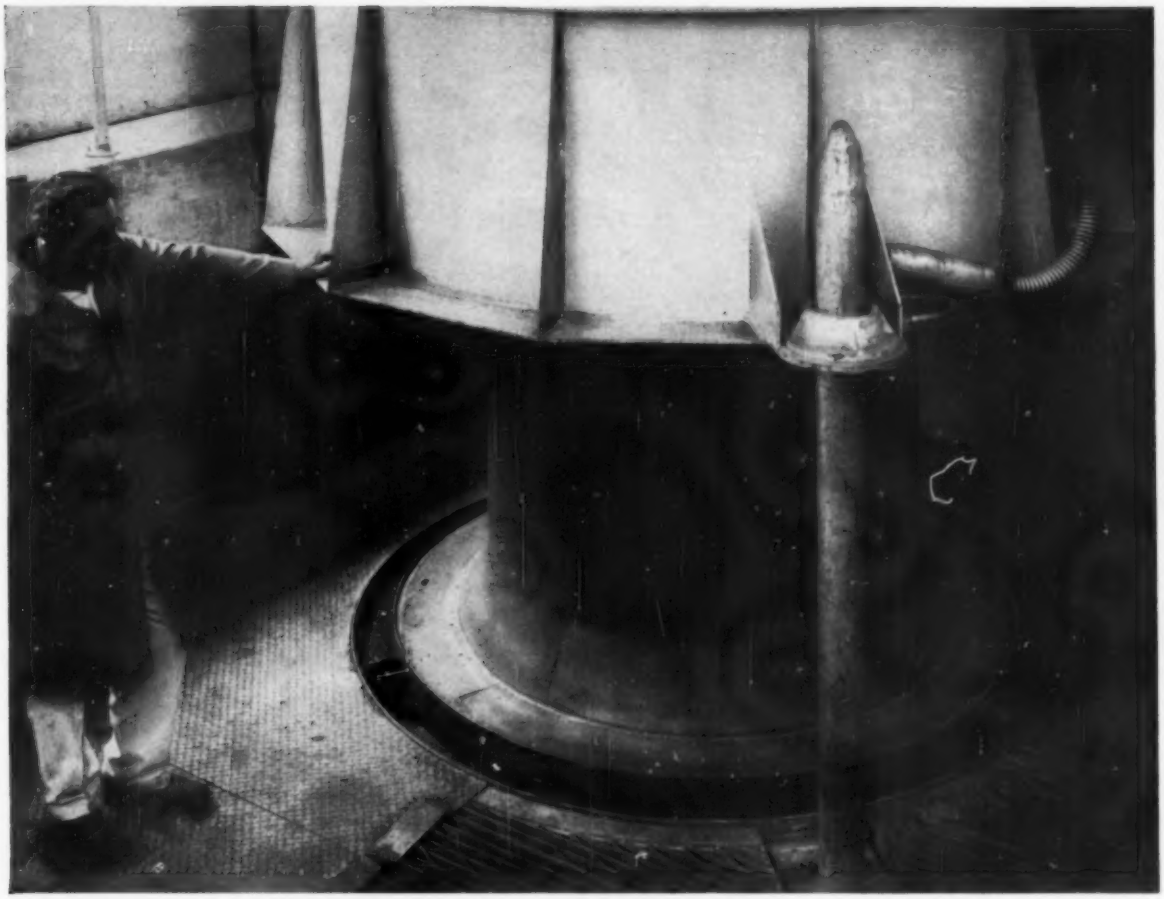
REFRACTORY PORCELAIN COMPANY
BEAVER FALLS, PENNA.



Hard to destroy! Easy to get! Long-lasting Inconel alloy retorts like this one at Harvey Aluminum, used for preheating, austenizing, quenching and tempering, can be produced by your regular heat treating equipment fabricator.

After 15 months of 1875°F heat treating...

Inconel Retort at Harvey Aluminum proves fully as good as it looks

Light, fast-heating retorts of wrought Inconel* nickel-chromium alloy prove amazingly durable.

Here (above) is one of several retorts at the Harvey Aluminum, Torrance, California plant which demonstrate the point. It was fabricated by California Alloy Products.

In service, retort is heated in a hurry . . . held there several hours . . . then cooled rapidly to one or two hundred degrees. Up again. Soak again. Down again. Cycle after cycle. All the while retort is under attack by atmospheric and furnace gases.

Harvey Aluminum, one of the major producers of wrought aluminum mill products, has many good words to say about the dependability of their wrought Inconel retorts. And about the high quality and long life of extrusion and forging dies produced in them. Die surfaces are excellent. Distortion is minimum. Shapes can be intricate.

Takes on many tough jobs

Where conditions are severe as in neutral salts bath pots, for example, or vertical furnaces, or tool carburizing baskets, or burning tools, or any one of thousands of items of heat treating equipment . . . Inconel alloy provides the dependability needed for profits and quality.

For the latest ways to shave costs with long-lasting Inconel alloy equipment, write Inco for "Keeping Costs Down When Temperatures Go Up."

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This steel casting is another example of Unitcast's ability to cope with unusual problems. As the main body of a new-type Pulsation Dampener for The National Supply Company's oil field equipment, this casting had many tough end-use requirements. Basically, the part had to absorb shock, withstand corrosion, and hold hydrostatic test pressures up to 8,000 psi. The fewer the components in the part, the better the durability.

The ideal solution, a one-piece steel casting, required accurate suspension of a huge core on a minimum number of points to produce a horizontal "tank" within consistent tolerances. One subsequent finishing problem involved economically "sealing" the core suspension holes by a method that would hold up in end use—*plus* pass radiographic inspection!

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Foundry . . .

The Staten Technological Institute at Oslo provides short courses on special subjects at all levels. Some of the large foundries do private research. There are two associations for foundrymen, the Norwegian Foundrymen's Assoc. and another primarily for the foremen. These are about to be united to form one organization having some 350 members and 100 firms.

H. J. ROAST

Heat Treatment of Toolsteels

Digest of "Tool Steels in Service", by A. P. T. Taylor-Gill, *Iron and Steel*, Vol. 30, December 1957, p. 631-635; Vol. 31, January 1958, p. 19-24.

WEAR RESISTANCE, shock resistance, machinability after treatment and heat resistance are properties which are normally required in toolsteels. The optimum values for each of these properties can be obtained by heat treating to provide a certain type of microstructure. However, since most tools require a combination of these properties, the heat treatment should provide a structure with the optimum combination of porperties. However, in all instances other than special purpose tools, it is recommended that the structure have maximum homogeneity, and the finely divided constituent particles should have the maximum usable hardness.

When steel is heated and cooled, substantial volume changes take place. If these changes do not occur uniformly, distortion or cracking may result. These tendencies can be greatly reduced by selecting a heat treatment designed to give a small temperature gradient and a homogeneous microstructure. The following is an outline of a general heat treatment which will produce the desired results if it is tailored to the steel to be used.

1. Heat from room temperature to 500 to 550° C. (930 to 1020° F.) using a forced air circulation or similar type furnace. Soak till the temperature is uniform.

2. Heat to 20° C. (70° F.) below Ac_1 for the steel being treated.

High Strength–Light Weight for use up to 2000°F.

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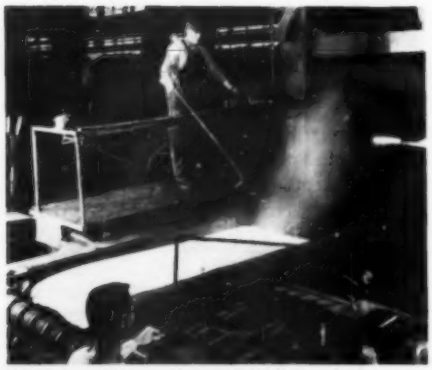
HAYNES high-temperature alloys are produced in many other forms, too. Sheet, plate, bar stock, wire, tubing, and castings are all immediately available. For full information write for descriptive literature.



High quality and availability of HAYNES wrought alloys are assured because they are produced in our own plant by experts. Sheet, above, is being hot-rolled on a 3-high mill.

HAYNES ALLOYS

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Division of Union Carbide Corporation
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Toolsteels . . .

Hold till the temperature equalizes. The type of furnace used will depend on the degree of surface protection desired.

3. Heat to the austenitizing temperature and hold for a sufficient length of time to allow the constituents to dissolve and diffuse through the austenite. The soaking time should be predetermined to avoid grain growth and overheating.

4. Cool from the austenitizing temperature to the interrupted quench or isothermal transformation temperature. Ordinarily this should be above the M_s point of the steel involved. However, if some distortion is permissible and a direct transformation to martensite is desired, the interrupted quench temperature may be below the M_s point but above atmospheric temperature. If bainite is desired, the quench should be interrupted somewhere between the bainite starting and finishing points. The steel should be soaked till transformation is complete.

5. The interrupted quench should take place approximately 30° C. (85° F.) above the M_s point and should be held until the temperature equalizes before cooling to room temperature. The isothermal transformation should take place in the lower bainite region and the steel should be soaked till transformation is complete.

6. Cool to atmospheric or subzero temperature.

7. Temper to desired degree of hardness. If this heat treatment is tailored to the steel, it will tend to reduce distortion and will help achieve a relatively homogeneous structure with low residual stresses. It also promotes a high surface density at all levels of hardness.

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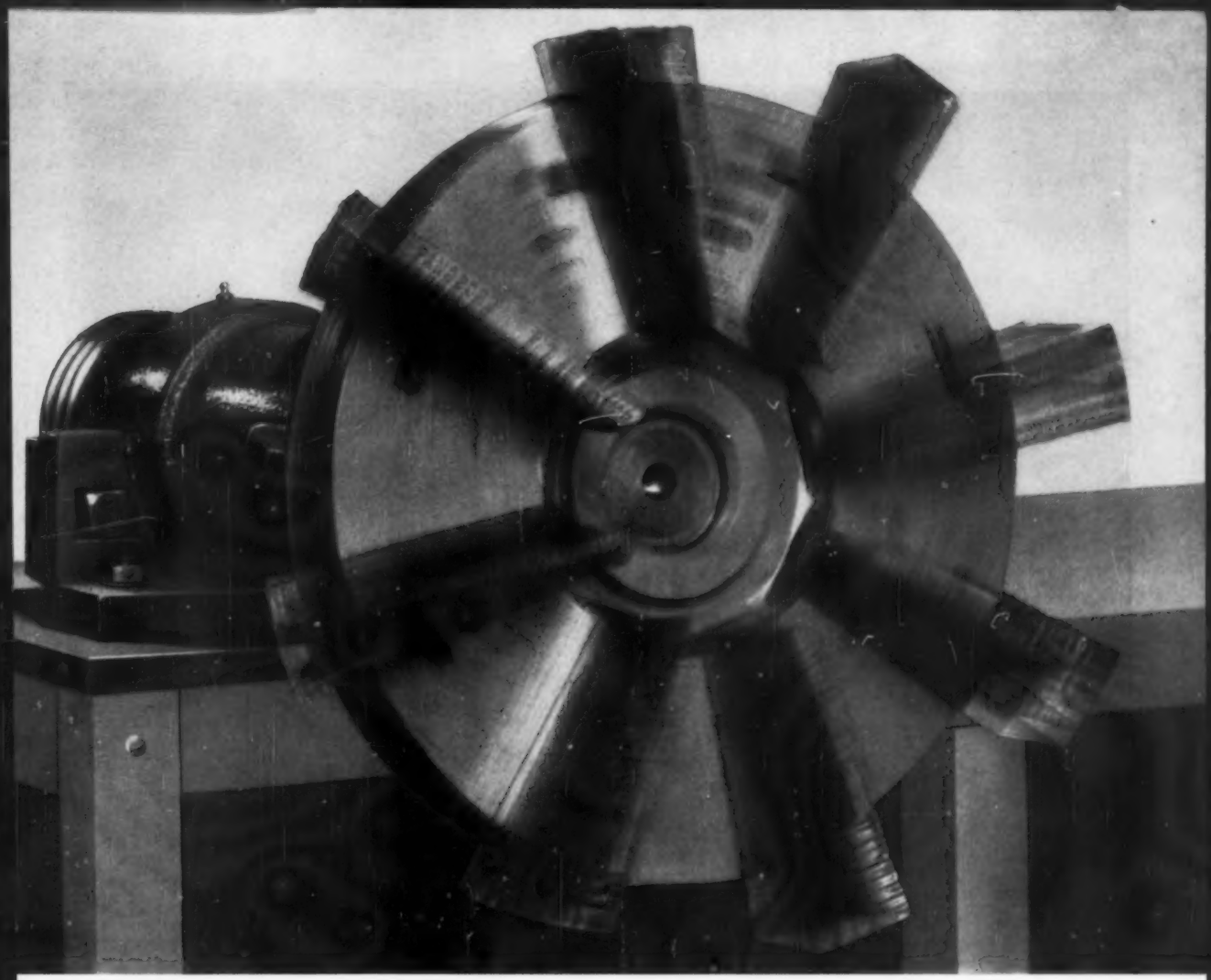
Carbon Dioxide Welding of Austenitic Steels

Digest of "The Question of CO_2 Welding Austenitic Steels and High-Temperature Alloys", by B. I. Medovar and I. N. Rublevsky, *Avtomaticheskaya Svarka*, No. 3, 1957, p. 70-84.

THE ARC WELDING of austenitic steels and high-temperature alloys is complicated by hot cracking and the necessity for special properties in the weld metal. The alloys are being welded with lime-basic electrodes (CaO-CaF_2 coating) and with submerged arc fluxes of which one (lime) is basic, low in silica, and the other (halide type) is free from oxygen. This paper presents test results showing the fields for which CO_2 welding is superior or inferior to the older processes.

In oxidizing capacity CO_2 is similar to argon plus 9% oxygen. Of the elements which are oxidized from austenitic steels by CO_2, titanium is most readily oxidized, its recovery being only 50%. Silicon and to a less extent manganese are also oxidized but not so strongly as titanium. Practically no chromium is lost, and carbon may increase 0.02 to 0.03%, at a content of 0.10%. The carbon pickup is a disadvantage

(*Continued on p.* 182)



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For inspection of welds, Kodak Industrial X-ray Film, Types AA, M, and KK, are available in the 70mm by 550 ft. package, as well as in standard sheet sizes.

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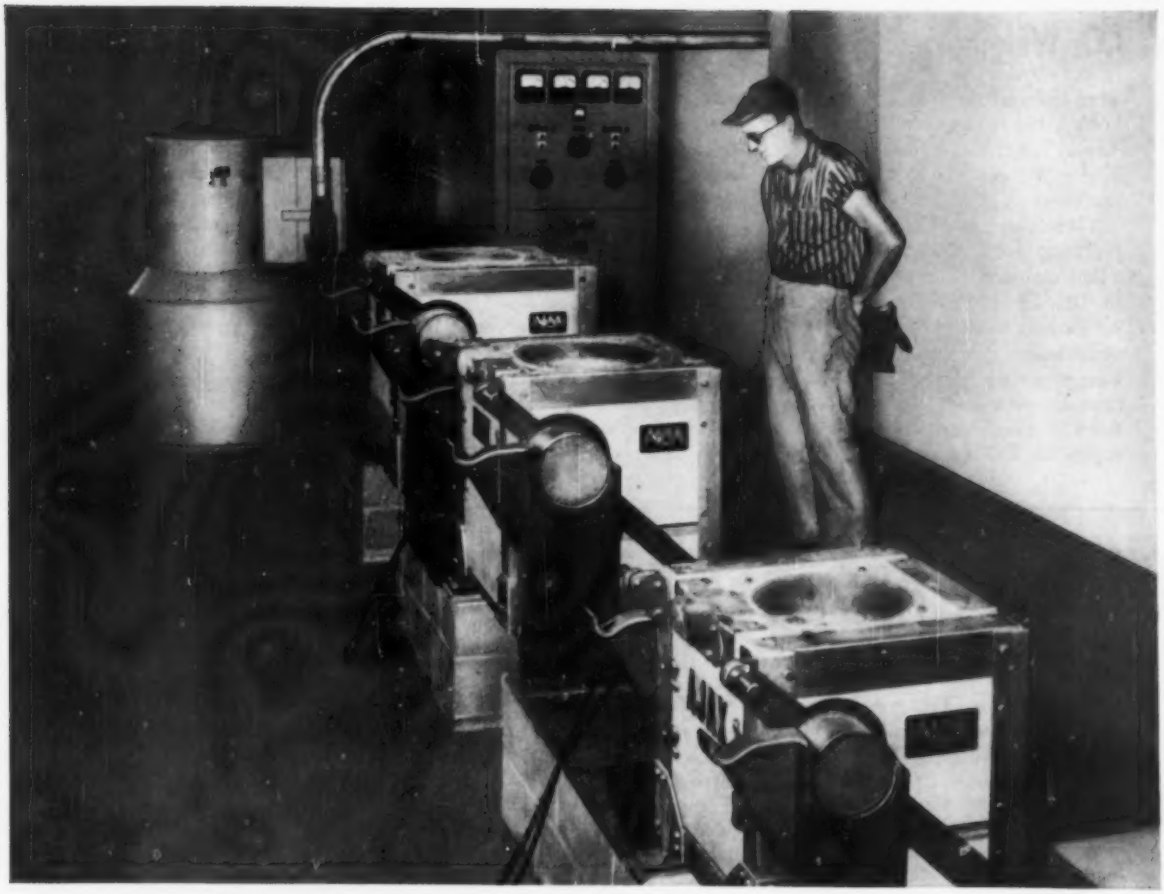

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CO_2 Welding . . .

when intergranular corrosion is involved, but is an advantage in overcoming hot cracks. The oxidation of silicon likewise assists in avoiding cracks.

There are two main welding problems with CO_2: spatter and adherent oxide. Spatter loss is 10 to 12% of deposited metal but is compensated by the 25% deeper penetration compared with submerged-arc welding. Stainless steel must be protected from spatter by strips of tough paper or a paint of waterglass and chalk or clay. The oxide is a spinel and is difficult to remove from the surface of the bead. High-silicon electrodes favor easy removal, while high chromium (25% Cr) accentuates adherence. To avoid the oxide film, a small quantity of fluoride flux (ANF-5) should be spread in front or in back of the arc. Only 6 to 10% of the quantity required for submerged-arc welding is needed.

Another limitation of CO_2 welding is its inability to produce butt welds of good appearance at currents over 500 to 600 amp. at slow travel speeds.

Submerged-arc welding with ANF-5 flux (80% CaF_2, 20% NaF) was compared with CO_2 welding for $\frac{5}{16}$-in. plates of titanium-stabilized Type 316 stainless steel. The welds were made with 0.079-in. Type 316 wire supplied at 200 in. per min., using 380 to 390 amp., 30 v. d-c., reverse polarity, 20 in. per min. travel speed, 32 cu.ft. per hr. CO_2. The submerged-arc welds were made in the same way except that the current was 10 to 15% lower. The weld metals had the following composition:

	CO_2	Submerged Arc
Carbon	0.10%	0.08%
Silicon	0.47	0.55
Manganese	0.95	0.97
Chromium	17.2	17.5
Nickel	12.7	12.0
Molybdenum	3.2	3.3
Titanium	0.15	0.22

Intergranular corrosion tests ($CuSO_4$-H_2SO_4, 72 hr. boiling, and HNO_3-NaF, two periods of 1 hr. at 175° F.) showed that the submerged-arc welds were superior because they were higher in titanium, lower in carbon than the CO_2 welds. In a general corrosion test (25% solution 40% acetic acid–60% formic acid, 24 hr. at 195° F.), the CO_2 welds were as good as the submerged-arc welds. The CO_2 welds had slightly higher tensile strength and as good ductility as the submerged-arc welds.

Three types of fully austenitic steels were welded with fully austenitic weld metal. In each instance CO_2 provided as high resistance to cracking as fluoride submerged-arc flux. The CO_2 lowered the phosphorus content, which is the most active element in cracking fully austenitic steel. Nickel-base alloys (80% Ni, 20% Cr) were welded successfully with CO_2, but in difficult turbine bucket joints the ductility was lower than with fluoride submerged-arc flux.

The quantity and type of nonmetallic inclusions were found to depend on the type of welding. Welds with the lowest inclusion content were made in argon. With siliceous submerged-arc fluxes there were large quantities of spherical inclusions. Fluoride flux produced a minimum number of inclusions, possibly particles of flux since oxidation did not occur. With CO_2, siliceous spheroids high in manganese were found in Types 308 and 310, changing to angular nitrides

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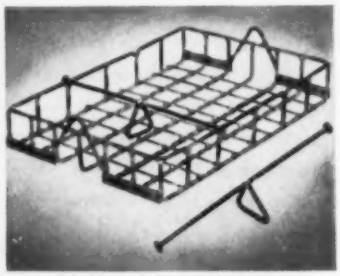

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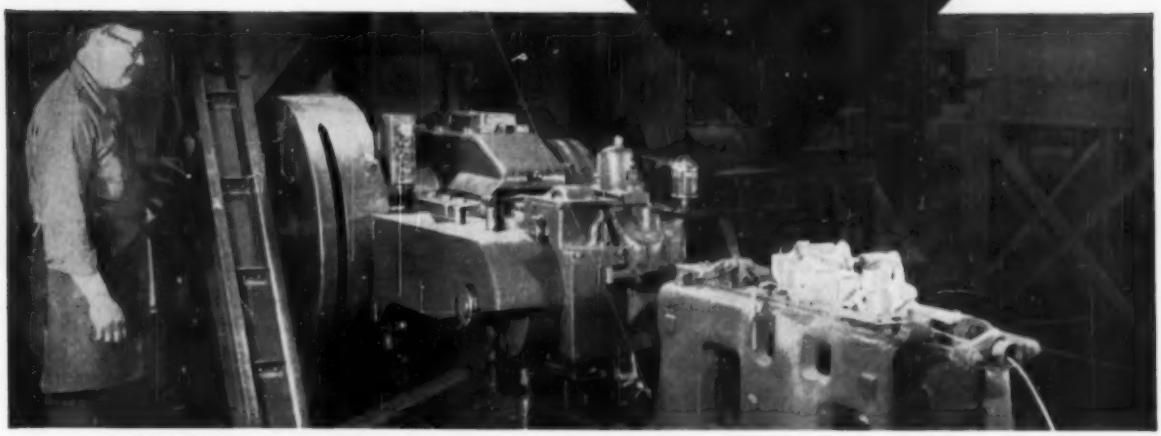

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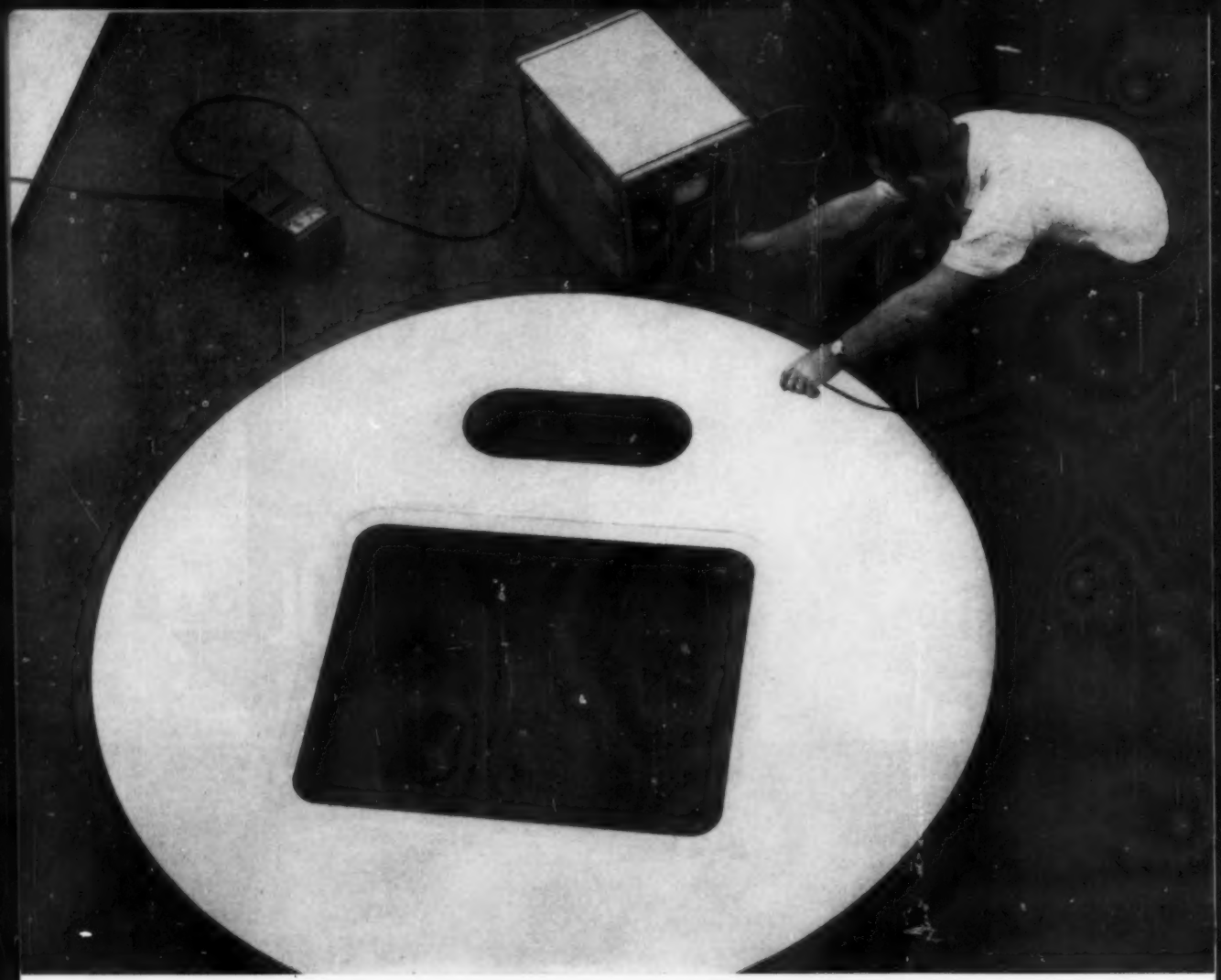

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CO_2 Welding . . .

and oxides with wire high in titanium and aluminum.

The tests showed that CO_2 welding should be recommended for fully austenitic steels, and that the wire should have a high content of stabilizers to offset loss and carbon pickup. A small quantity of flux should be used in multilayer welds to facilitate bead cleaning and to avoid slag inclusions.

D. L. CHURCHILL

Nickel-Phosphorus Alloy Coatings

Digest of "Influence of Heat Treatment on the Properties of Chemical Nickel Coatings Produced by the Kanigen Process", by Van Royen, *Electroplating and Metal Finishing*, Vol. 10, April 1957, p. 114-115.

KANIGEN is General American Transportation Corp.'s trade name for nickel-phosphorus alloy coatings produced by a catalytic chemical reduction process. These coatings, as deposited, have a lamellated structure indicating periodic variations in the phosphorus content. The lamellas have a thickness of 0.02 to 0.03 mil and contain from 7 to 10% phosphorus. X-ray diffraction studies have shown the structure to be amorphous as deposited. When this alloy is melted and cooled to room temperature, the structure appears under the microscope as primary dendrites of nickel in a eutectic of Ni and Ni_3P.

The hardness of electrodeposited nickel from a Watts bath ranges from Vickers 140 to 250. The Kanigen coating has an initial hardness of approximately Vickers 500. Heat treatment transforms this coating from an amorphous state to a phase mixture of crystalline nickel and Ni_3P. At 390° F. and below, the amorphous state is stable for at least 21 hr. Above 390° F., transformation proceeds at a controllable rate. Maximum hardness of Vickers 1050 may be expected by heating Kanigen to 750° F. for 10 min. and cooling to room temperature. This hardness value is about the same as that of

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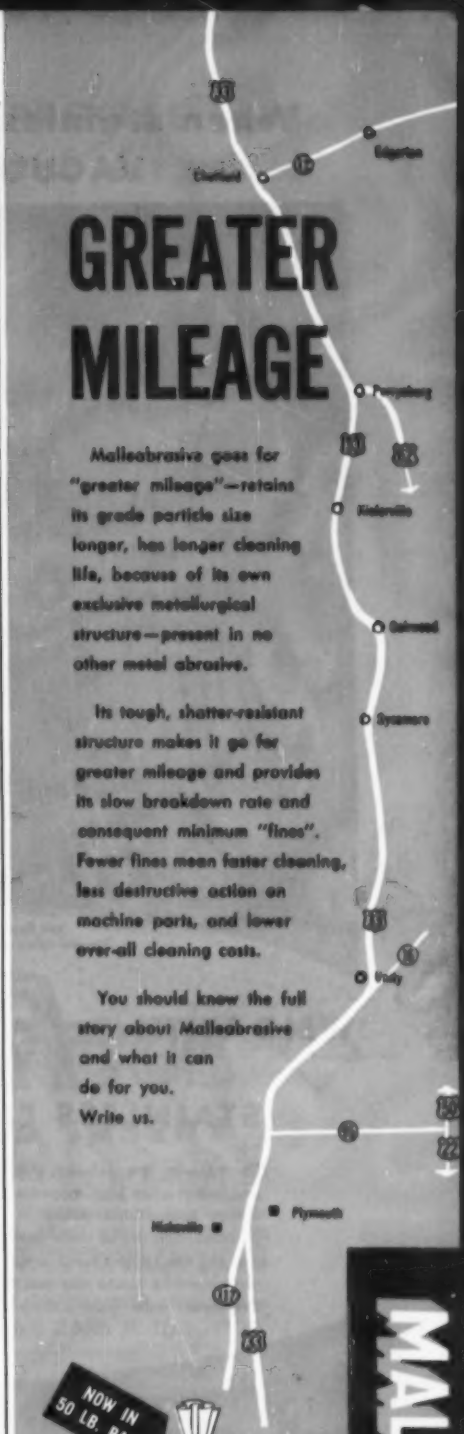
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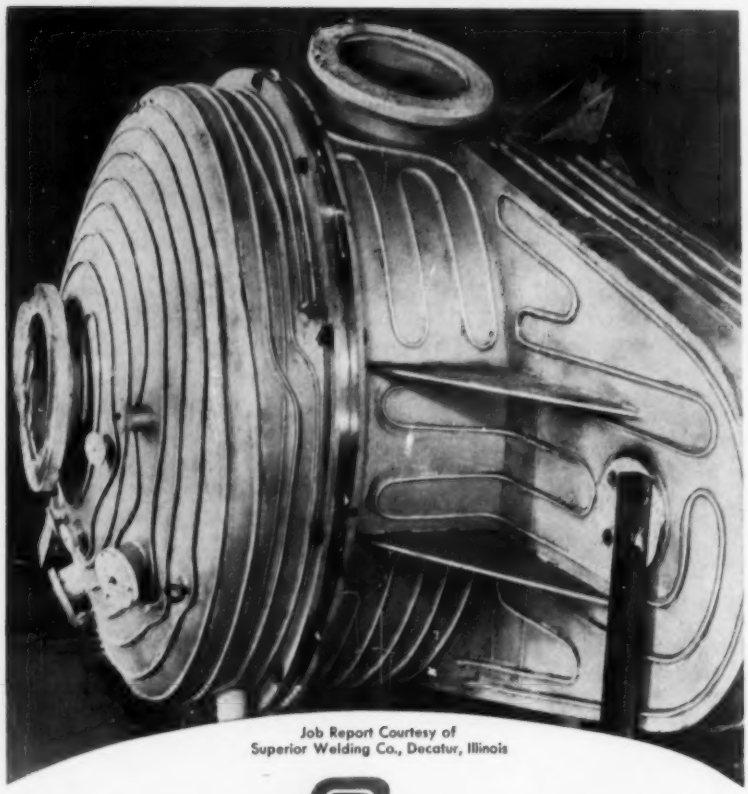

Job Report Courtesy of
Superior Welding Co., Decatur, Illinois

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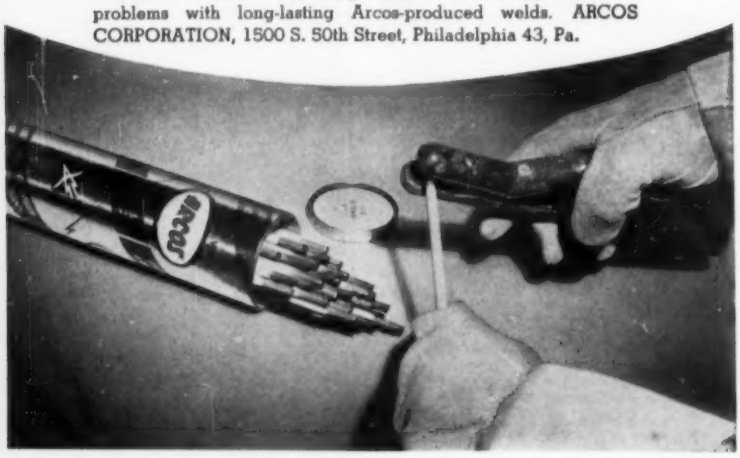

Nickel Coatings . . .

hard chromium. At temperatures higher than 750° F., the particle size of the Ni_3P phase increases and superficial hardness decreases below Vickers 600 at 1380° F. Treatment at 1380° F. yields a homogenous structure. In this condition the corrosion resistance is at a maximum. This is possibly due to the release of internal stresses.

Three practical heat treatments are suggested by the author, and should be used according to the anticipated service of the coated parts.

1. Maximum hardness is achieved by heating the deposits to 750° F. for 1 hr. in an inert atmosphere. One may expect a hardness up to Vickers 1050. Coatings treated in this manner could be competitive with hard chromium.

2. Maximum corrosion resistance may be obtained by treating the deposits at 1380° F. for 5 hr. in an inert atmosphere followed by slow cooling to 390° F. The application of the treatment may be limited by the mechanical property requirements of the basis material.

3. Maximum wear resistance is claimed when Kanigen is treated at 1110° F. for 90 min. This is a compromise between maximum hardness and maximum ductility.

The author shows the corrosion resistance of Kanigen to various common reagents. Values are given for Kanigen as deposited and after heat treatment for maximum corrosion resistance.

W. H. METZGER

Volumetric Determination of Silicon in Ferrosilicon

Digest of "Methods for the Rapid Determination of Silicon in Ferrosilicon", by Sigurd Velken, *Journal*, Iron and Steel Institute, February 1958, p. 119-121.

THE USUAL METHOD of determining silicon in ferrosilicon is to fuse the alloy with an oxidizing flux and then dissolve the fusion in an excess of hydrochloric or sulphuric acid, and evaporate to dryness. The pre-

Ferrosilicon . . .

cipitated silica is collected on a filter, washed and ignited, and the silica calculated as the loss in weight by treatment with hydrofluoric acid. The filtrate and washing contain small amounts of colloidal silica, and in accurate work the greater part of this is rendered insoluble by a second treatment. These methods of dehydration and evaporation are slow and at least 24 hr. are required to complete the determination.

Two new methods based on the formation of K_2SiF_6 eliminate the gravimetric weighing of silica and enable rapid titration of the fluosilicate. The two methods are given below:

Method 1 – Thoroughly mix 0.2 g. finely ground ferrosilicon, grade 75% silicon, with 2.5 g. fusion mixture in a nickel crucible. Use a platinum wire for the mixing. Add a surface layer of 2.5 g. fusion mixture and cover the crucible with a nickel lid. (For ferrosilicon of other grades adjust the sample weight to give the same amount of silicon.)

Fuse as described. While the crucible and lid are still warm, place both in a 250-ml. plastic beaker and extract with water. Rinse the crucible and lid with hot water and a little nitric acid. Add 35 ml. nitric acid and if necessary dilute with water to about 80 ml.

Add 6 g. potassium chloride, dissolve, and allow to cool. If the volume is more than 80 ml., proportionate amounts of potassium chloride and nitric acid should be used.

Stir in 10 ml. hydrofluoric acid and a little paper pulp. Cool the solution to as low a temperature as possible, preferably in ice water, for 10 to 15 min., stirring occasionally. To accelerate the quantitative precipitation of the potassium fluosilicate, it may be advantageous to use a stirring motor with a plastic stirrer. Three minutes at 500 to 1000 rpm. will be sufficient and the solution may be filtered immediately if it is sufficiently cool.

Filter on a paper pulp pad in a plastic funnel. Transfer the entire residue to the pad and wash the beaker and pad with cold potassium chloride (20%). Use as little washing solution as possible, preferably

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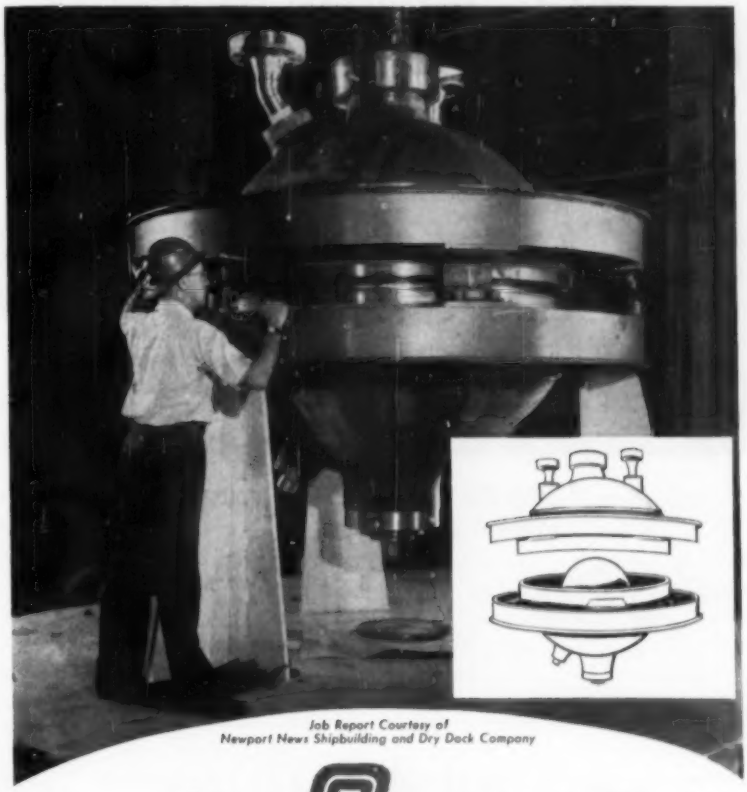

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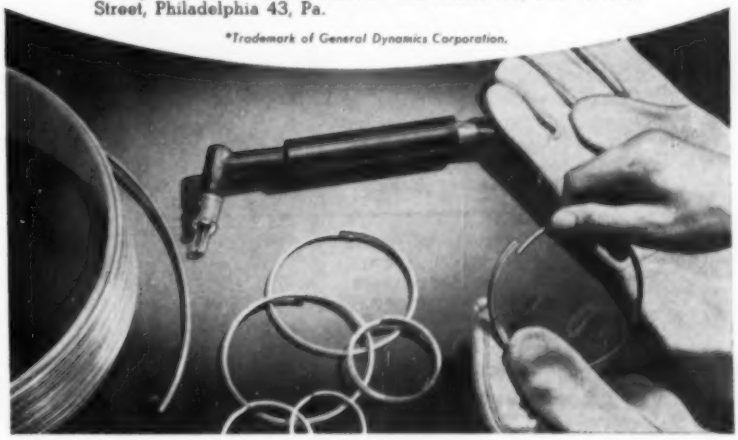

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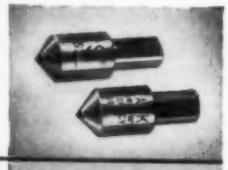

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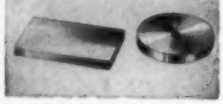

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less than 100 ml. Precipitate and pad are sufficiently washed when 10 ml. of the washing solution become alkaline to methyl red on the addition of one drop of 0.25 *N* sodium hydroxide. Remove the liquid in the stem of the funnel by slight suction and transfer pad and precipitate to a 300-ml. Erlenmeyer flask. Remove the last traces of precipitate from the funnel with a piece of filter paper moistened with water, place the funnel in the neck of the Erlenmeyer flask, and rinse down with 50 ml. of hot water (previously boiled). Shake the flask to disintegrate the pad and titrate with 0.25 *N* sodium hydroxide in hot, nearly boiling solution to a pink color. As an indicator, use ten drops of phenolphthalein (1%). Heat the mixture to boiling for a short period during which the color should be retained. Alternatively, continue titration until the pink color persists on heating.

1 ml. 0.25 *N* NaOH = 0.0017538 g. Si

Time required: 1 hr.

Method 2 – Into a plastic beaker weigh 0.2 g. ferrosilicon, grade 75% silicon, and cautiously add 30 ml. nitric acid (sp.gr. 1.4). Then pour 10 ml. hydrofluoric acid (40%) down the side of the beaker. If both additions are carefully done, the reaction will proceed slowly without any danger of vigorous effervescence. To start the reaction, it may be necessary to agitate the beaker a little.

When the reaction has subsided, agitate the beaker for a few seconds to expel most of the nitrous gases and to dissolve any remaining particles. Rinse the sides of the beaker with 20 ml. of water and add, with stirring, 30 ml. potassium chloride (20%) and a little paper pulp, and cool. Then proceed as described under Method 1.

The values obtained for silicon in ferrosilicon by both modifications of the method are in good agreement with the values obtained from careful gravimetric determinations. The methods are much more rapid and can be used for determinations of silicon in other ferro-alloys, for example, silicomanganese and silicochromium.

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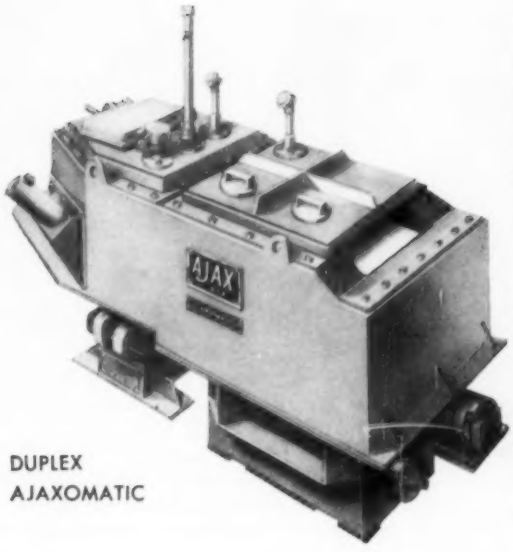

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Notes About Authors

Dr. Hollomon (Second From Left) Shown With Members of U.S.S.R. Academy of Sciences. (Left to Right) A. M. Samarin, G. V. Kurdjumov and Dr. Bardin

H. W. Balster

More than 30 years experience in the German steel industry served as background for H. W. Balster's review of German steelmaking. He was graduated from the Technische Hochschule in Aachen in 1927 and immediately went into the Hoesch steel works as a metallurgist. Following an eight-year stint as chief metallurgical engineer of the Ford Motor Co. in Cologne, Germany, he became connected with Ruhrstahl A. G. of Witten in 1942. He joined the main company as chief of development and research and three years later was named technical director of the Annener Gussstahlwerk division. In 1955 he was again transferred back to the main company as director of development and research. He now holds the same position in the Rheinische Stahlwerke in Duesseldorf.

He was awarded a doctor of engineering degree in 1941.

F. P. Heard

F. P. Heard began his metallurgical career in 1933 on the staff of H. V. McKay Massey Harris Pty. Ltd. in Sunshine, Victoria, Australia, first as a chemist and later as a metallurgist. During this time he studied chemistry and metallurgy at Melbourne Technical College, receiving his degree in 1941. There followed an appointment to the Commonwealth Government Small Arms Factory in Lithgow, N.S.W., as metallurgist in charge of the metallurgical laboratory and the metal finishing department. Following five years with Standard Telephone and Cables Pty. Ltd. in Sydney, in 1951 he took his current position as chief metallurgist with Borg-Warner (Australia). He has been closely associated with controlled atmosphere heat treatment, and Borg-Warner has the first continuous type gas carburizing furnace in Australia.

J. Herbert Hollomon

J. Herbert Hollomon, whose article "Metallurgy in the U.S.S.R." is based on his recent trip to Russia, is manager of the metallurgy and ceramics department of the research laboratory of General Electric Co. in Schnectady, N. Y. Dr. Hollomon has been affiliated with G. E. since 1946, when, after his release from the armed forces, he joined the Knolls Atomic Power Laboratory as metallurgical advisor. He later served as manager and assistant manager of the research laboratory's metallurgy department.

F. Charles Thum

F. Charles Thum is the son of the Editor-in-Chief of *Metal Progress*. He has an architectural degree from Princeton University, and also received a scholarship in architecture for 1936-39, studying at the Beaux Arts in Paris and traveling in Europe until the war broke out. He returned to France shortly after the landings in Normandy and supervised the American Friends Service Committee's relief work in the South of France. From 1950 to 1952 he was with the American Battle Monuments Commission, designing and erecting caretaker's housing at the various cemetaries; from 1952 to 1954 he was at the U. S. Embassy in Paris constructing new embassies and diplomatic residences in Western Europe; and from 1954 to 1958 he was supervising architect on the construction of the headquarters building for North Atlantic Treaty Organization in Paris. He now resides in the ancient French basilica town of Vezelay in central Burgundy. (*Cont. on p.* 192)

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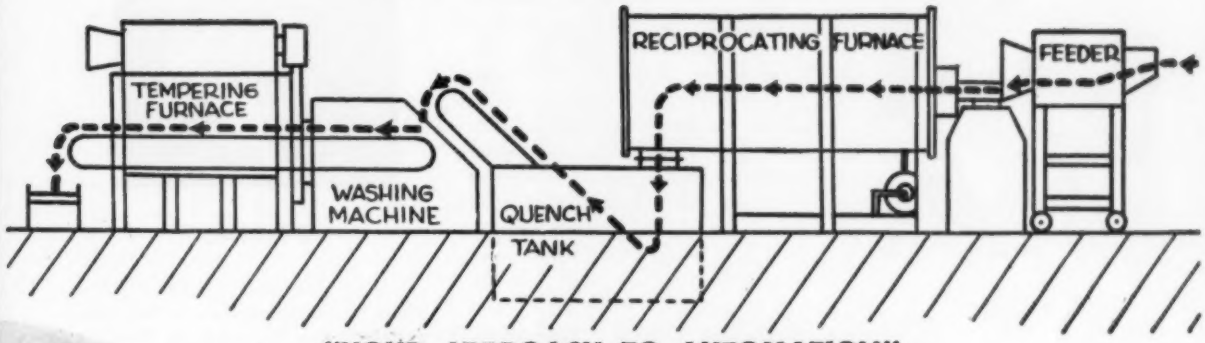

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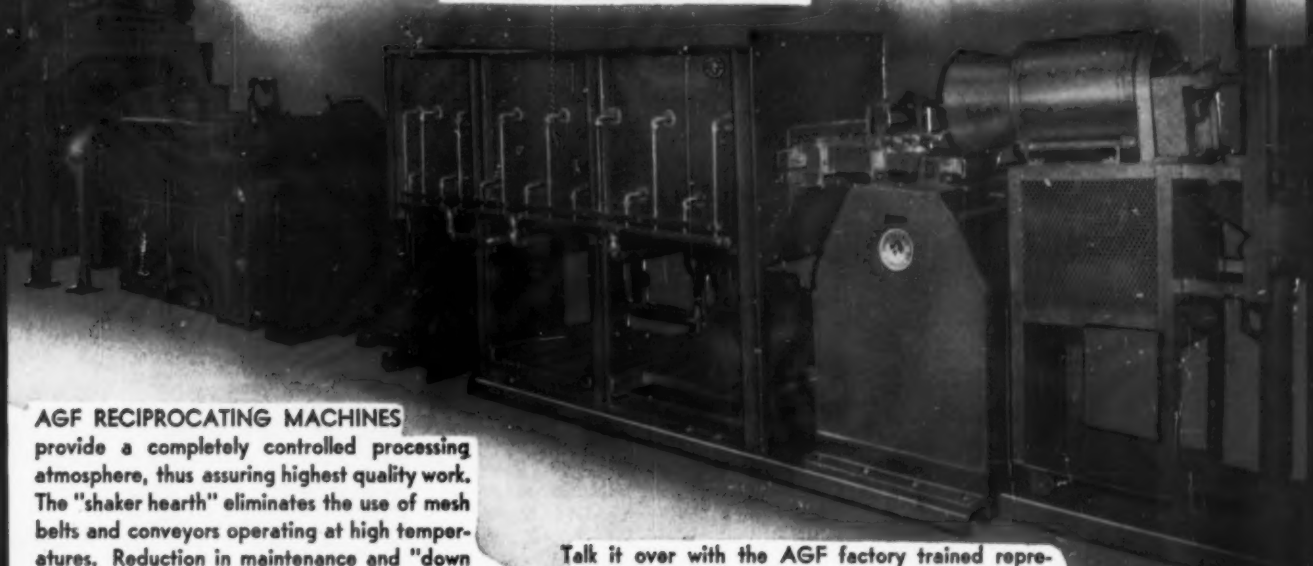

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D. W. Gillings

D. W. Gillings joined the British Iron and Steel Research Assoc. at the end of World War II, working in full-scale plant investigations on blast furnaces, sintering and ore preparation plants. In 1949 he moved to the British Coal Industry and, after some months' work on underground mining problems, became head of carbonization research at the Coal Research Establishment in Stoke Orchard, conducting research on metallurgical coke and smokeless fuels at laboratory, pilot-plant and experimental production stages. He is now a consultant on process control developments in the chemical industry.

John P. Howe

John P. Howe, whose report of the Second Conference on the Peaceful Applications of Atomic Energy at Geneva appears on p. 106, is chief of research of Atomics International (a division of North American Aviation, Inc.) in Canoga Park, Calif., where he has been devoting attention to varied nonmilitary uses of nuclear energy since 1953. His interest in nuclear energy is further evidenced by his membership in the Committee of Senior Reviewers – an advisory panel on classification for the A.E.C. – and on the editorial board of reactor handbooks sponsored by the A.E.C. After six years teaching experience, Dr. Howe joined the Manhattan District Project's metallurgical laboratory as a research associate, rising to associate director of the laboratory in 1945. At that time he left to join General Electric Co., working in the company's research laboratory and at the Knolls Atomic Power Laboratory in Schenectady, N.Y.

David A. Keys

David A. Keys has been associated with Canada's Chalk River, Ontario, atomic energy project since 1947. Until that time his career had been primarily devoted to teaching physics at McGill University, first as assistant professor in 1922, rising to associate professor in 1926 and finally full professorship in 1929. In 1941 he was named McDonald Professor of Physics. He left McGill in 1947 to act as vice-president (scientific), National Research Council, in charge of the Atomic Energy Project at Chalk River, Ont. In 1952 he was named chairman of the project coordinating committee of Atomic Energy of Canada Ltd., the government organization now administering the project, and since 1953 has been scientific adviser to the president.

D. A. Robins

Among the participants at the Third International Plansee Seminar in Reutte, Austria, was D. A. Robins, whose report of the meeting begins on p. 84. Dr. Robins, who was co-author of a paper presented there on high-purity refractory metals, is a senior metallurgist in the metallurgical research group of the General Electric Co. Ltd. laboratories in Wembley, England. To date, his entire professional career has been spent with the G.E. laboratories which he joined in 1942 as a student assistant. Studying part-time, he earned a general bachelor of science degree from London University and two years later an honors bachelor's degree in physics. He recently received his doctor's degree from the same school.

Friedrich Foerster

Well-known as an authority on nondestructive testing throughout the metallurgical world, Dr. Foerster now heads the Institute Dr. Foerster in Reutlingen, Germany. Prior to

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World War II he was long associated with the Kaiser-Wilhelm-Institute for Metal Research in Stuttgart where he conducted extensive research on nondestructive testing, particularly eddy current testing. Dr. Foerster was supervisor of the department of physics when the war ended and the Institute was dismantled and transported to France. After several years working privately on special developments in the nondestructive field, in 1948 he founded a laboratory which expanded into the new Institute Dr. Foerster.

R. A. King

After graduating from the University of British Columbia with a chemical engineering degree in 1936, R. A. King came to Consolidated Mining and Smelting Co. of Canada Ltd. in Trail, B. C., and there he has remained for more than 20 years. His work has included analytical laboratory research, plant testing and chemical control operations and, for the past 13 years, research and development, particularly on high-purity metals.

Ariel Taub

Ariel Taub is currently occupying the Arturo Gruenbaum Chair of Mining and Metallurgy for advanced studies at the Technion, the Israeli Institute of Technology, and is at the same time acting director of the Israeli Institute of Metals, heading its laboratory for heat treatment and metallography. In addition he serves as editor of the Institute

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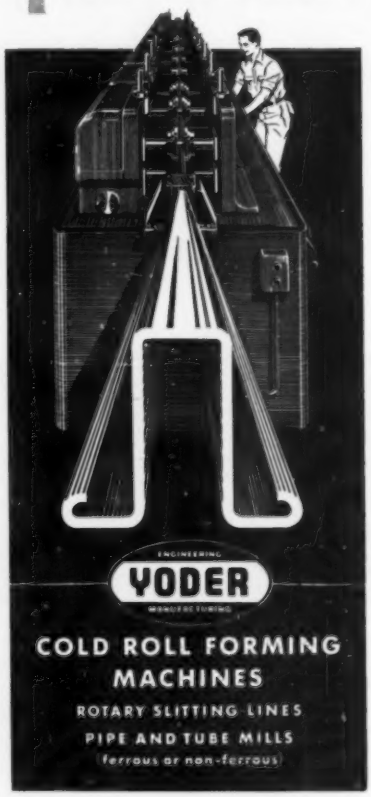

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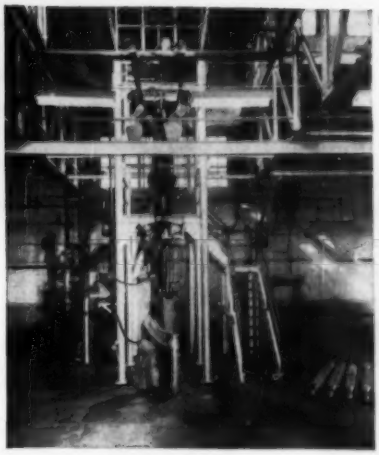

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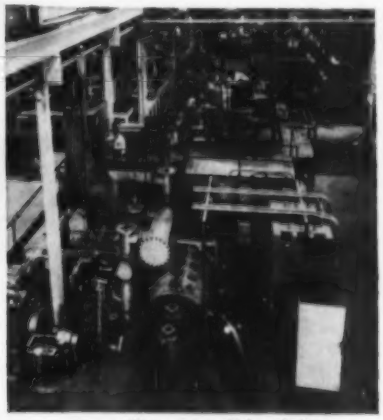

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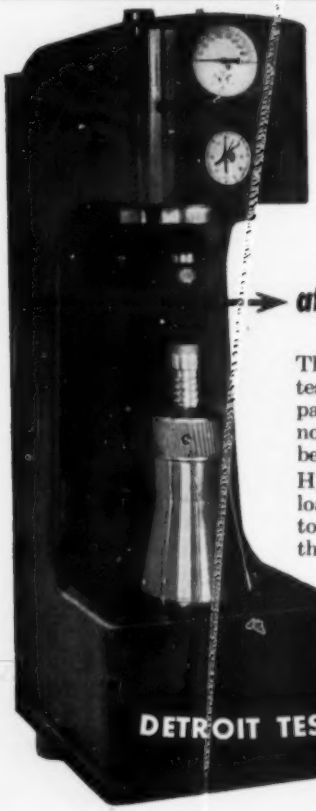

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Authors . . .

quarterly bulletin *Metals*. He is therefore in an especially good position to survey the metallurgical progress made in Israel during the country's first ten years.

J. C. Chaston

J. C. Chaston is ably qualified to discuss the first 50 years of the Institute of Metals for, as a former member of the Council of the Institute and former chairman of the London Local Section, he is an active member, well versed in Institute history. He has been in charge of metallurgical research for Johnson, Matthey & Co. – a name synonymous with platinum and other precious metals to Britishers – since 1938, the last five years as manager of the research laboratories. He received his degree from the Royal School of Mines in London and from 1925 to 1936 worked for Standard Telephone & Cables; then for two years he was a lecturer at the Royal Technical College in Glasgow.

(*Continued on p.* 198)

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Authors . . .

A. Decker

A. Decker has been engaged in research in process metallurgy and physical chemistry for the Liège, Belgium, section of the Centre National de Recherches Métallurgiques for the past eight years, and since 1957 has served as head of this research field at the Institute. He received his civil engineering degree from Liège University in 1949 and his doctorate in 1956.

Arthur B. Tesmen

Born in China, Arthur Tesmen received his primary schooling there, including instruction in the Russian language. This knowledge stood him in good stead, when as a member of the United States group attending the conference on Vacuum Techniques in Steel held in Moscow, he visited Russia last summer. Now a metallurgical engineer with Loewy-Hydropress Div. of Baldwin-Lima-Hamilton Corp., Tesmen was with North American Philips Co., Inc., from 1947 to 1952.

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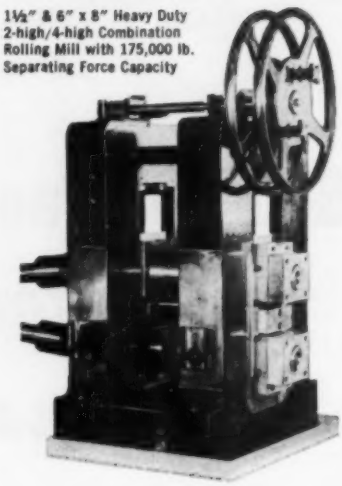

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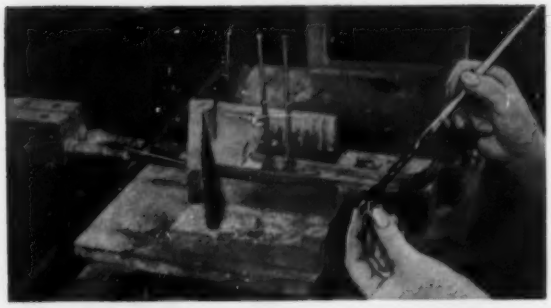
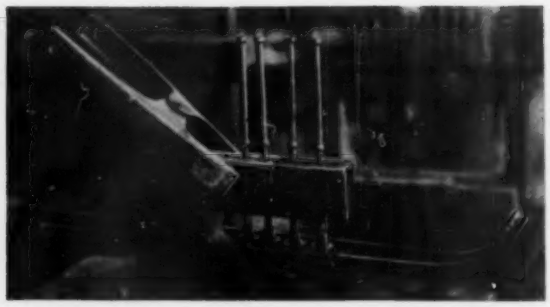


Operator applying Special Handy Flux Type B-1 to components of de-icer tube before brazing.



Here, four de-icer assemblies in jig are being brazed by induction heat.

First step in brazing manifold. Operator applies Special Handy Flux Type B-1 to joint area prior to hand brazing. B-1 Flux is particularly effective in removing refractory oxides such as those formed in stainless steels and carbides.

Operator preheats joint area before hand feeding Handy & Harman silver alloy Braze 541.

Here, two different parts are being brazed. Operator in foreground hand feeds alloy on aircraft manifold joint while operator in background brazes nipple on hydraulic oil filter. Gas-air hand torches are used in both cases.

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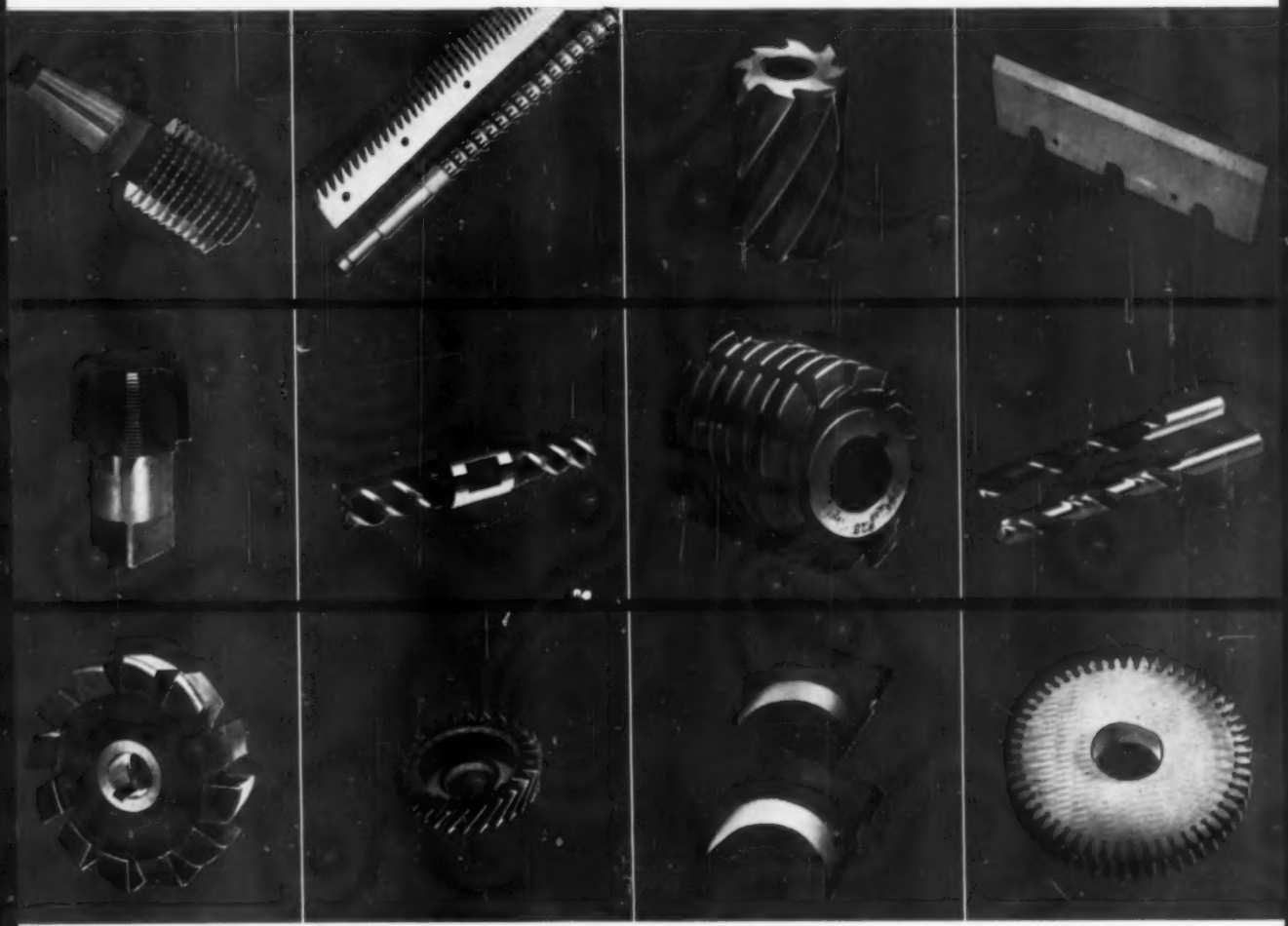

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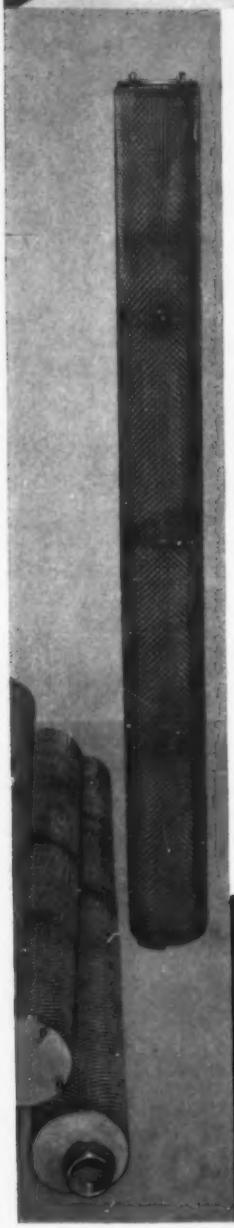

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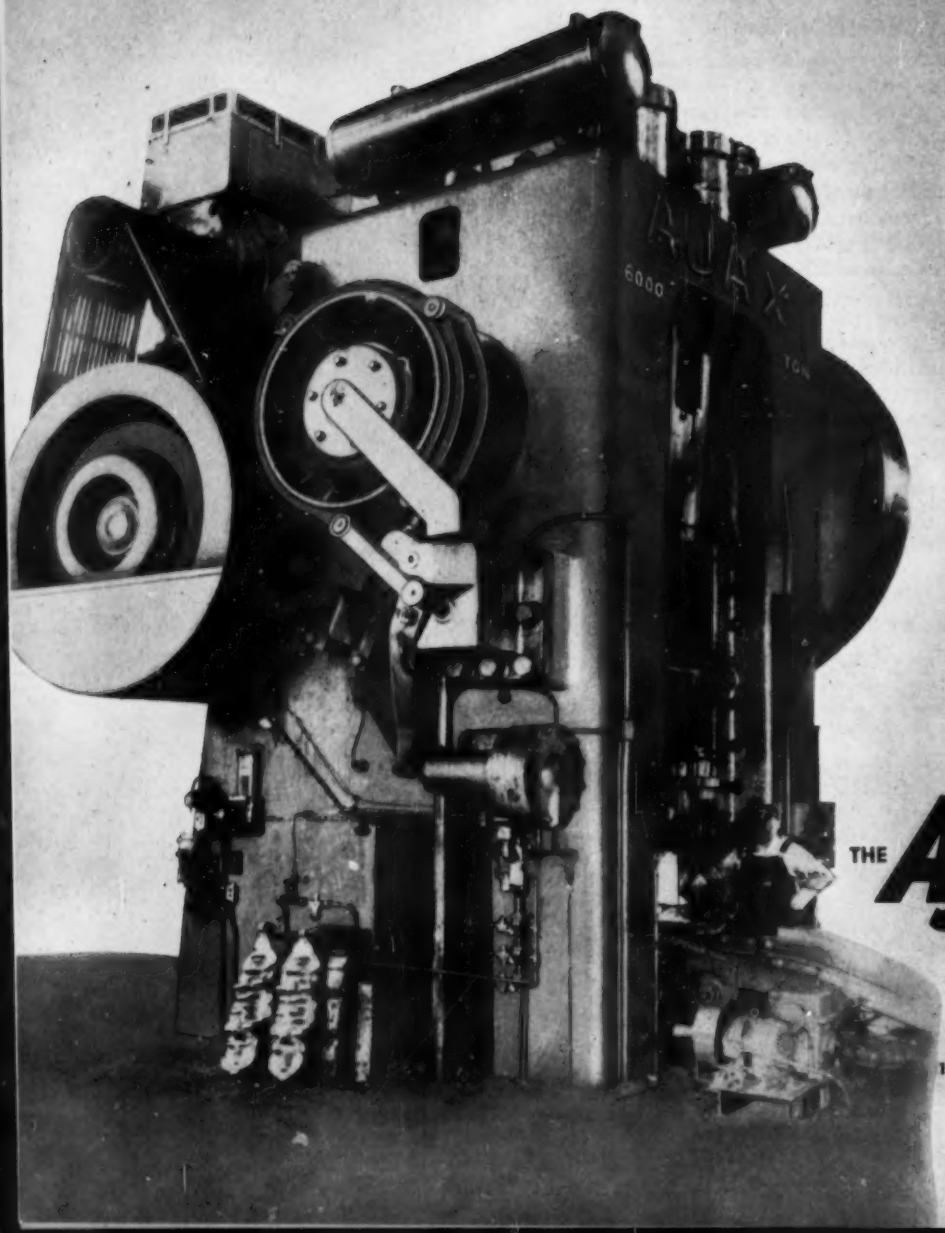

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Refractory Carbides	Low binder content. High melting point — 5000° F to 7000° F.	Crucibles. Acid resistant parts. High temperature furnace parts.
Heavy Tungsten Alloys	Nominal Density: 16.5 to 18.7 gm/cc. Machinability: Good. Tensile Strength: 40,000 to 90,000 psi. Corrosion Resistance: Excellent. Readily brazed with Easy-Flo No. 3 Compound. Available as bars, rods, rings, discs, special shapes.	Counterweights. Radioactive shielding. Isotope containers. Atomic watch shielding. Shielding — cobalt and X-ray medical equipment. Rotational parts — flywheels, governors, gyroscope components. Electrical contactors for high current heavy duty applications.
Niobium	Metal — 99.8% grade. Granules, arc melting electrodes, bar, strip, foil. Metal — 99.5% and 98.5% grades. Powders, granules, arc melting electrodes. Oxide — 99% and 99.5% grades. Fine powder.	Bars: Nominal size ½" x 2" x 19". Other sizes available. Strip, Foil: .001" to .100" thick, up to 4" wide. Powders: 20 to 80 mesh. Granules: ⅛" to 40 mesh.
Tantalum	Metal — 99.9% (capacitor) grade. Solid form — strip, bar, foil, wire. Metal — 99.5% grade. Granules. Metal Powder — 99.8% grade. Fine powder. Oxide — 99% grade. Fine powder.	Bars: Nominal size ½" x 2" x 19". Other sizes available. Strip, Foil: .001" to .100" thick, up to 4" wide. Wire: From .005" to .030". Granules: 20 mesh. Other sizes and grades available. Powder: 200 mesh. Other sizes available. Oxides: In analyses and particle sizes to meet specific requirements.
Kenspray (hard surfacing material)	Powder applied by hand or mechanically-held metal spraying equipment. May be successfully applied to irregular shapes or flat surfaces. Only thin coating required (from .010" to .090"). Conserves material, provides uniform surface. After spraying application, part is heated to fuse the hard surfacing deposit to its base. For close tolerances, part may then be ground with silicon carbide wheels.	Machine components and equipment for food, chemical, petro-chemical, other processing industries . . . Cams, valve seats, sleeves, shafts, dies, guides, jigs, process rolls, wear strips, valve plugs and bodies, grain mill hammers, pump parts, agricultural equipment.
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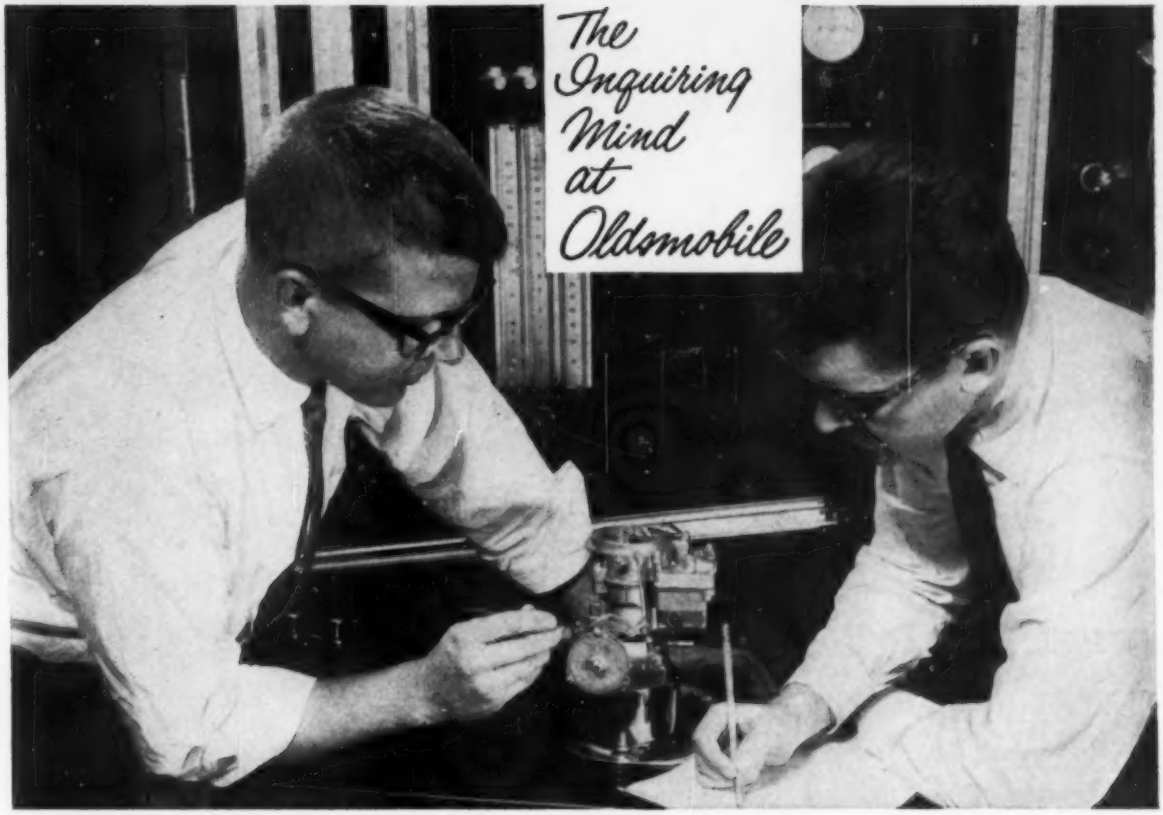

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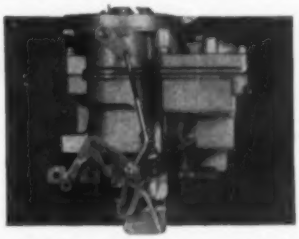

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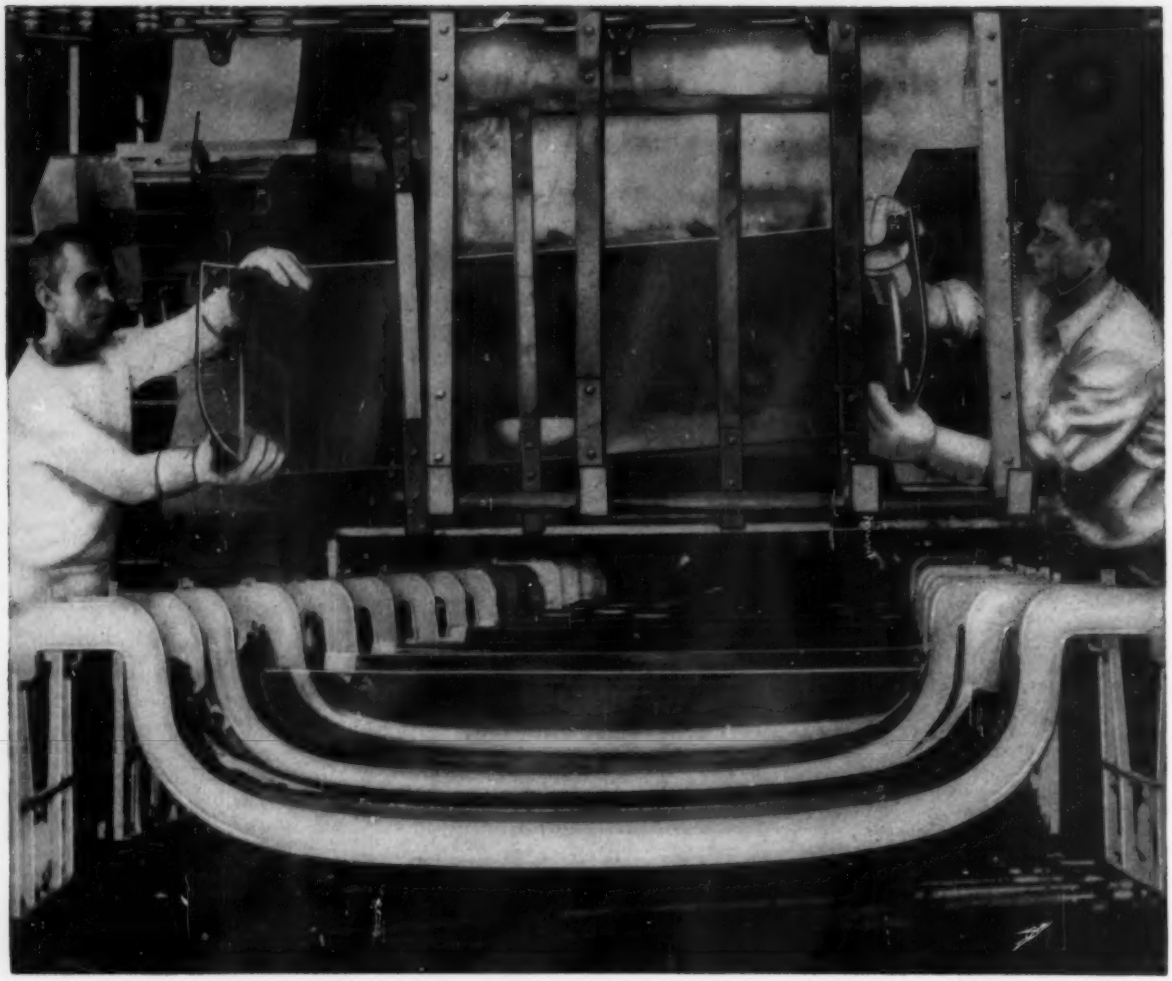

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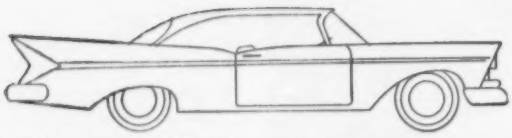

With nearly 7,000,000 cars being produced annually, the increased use of glass has demanded major production improvements in the manufacture of new panoramic windshields and back-lights.

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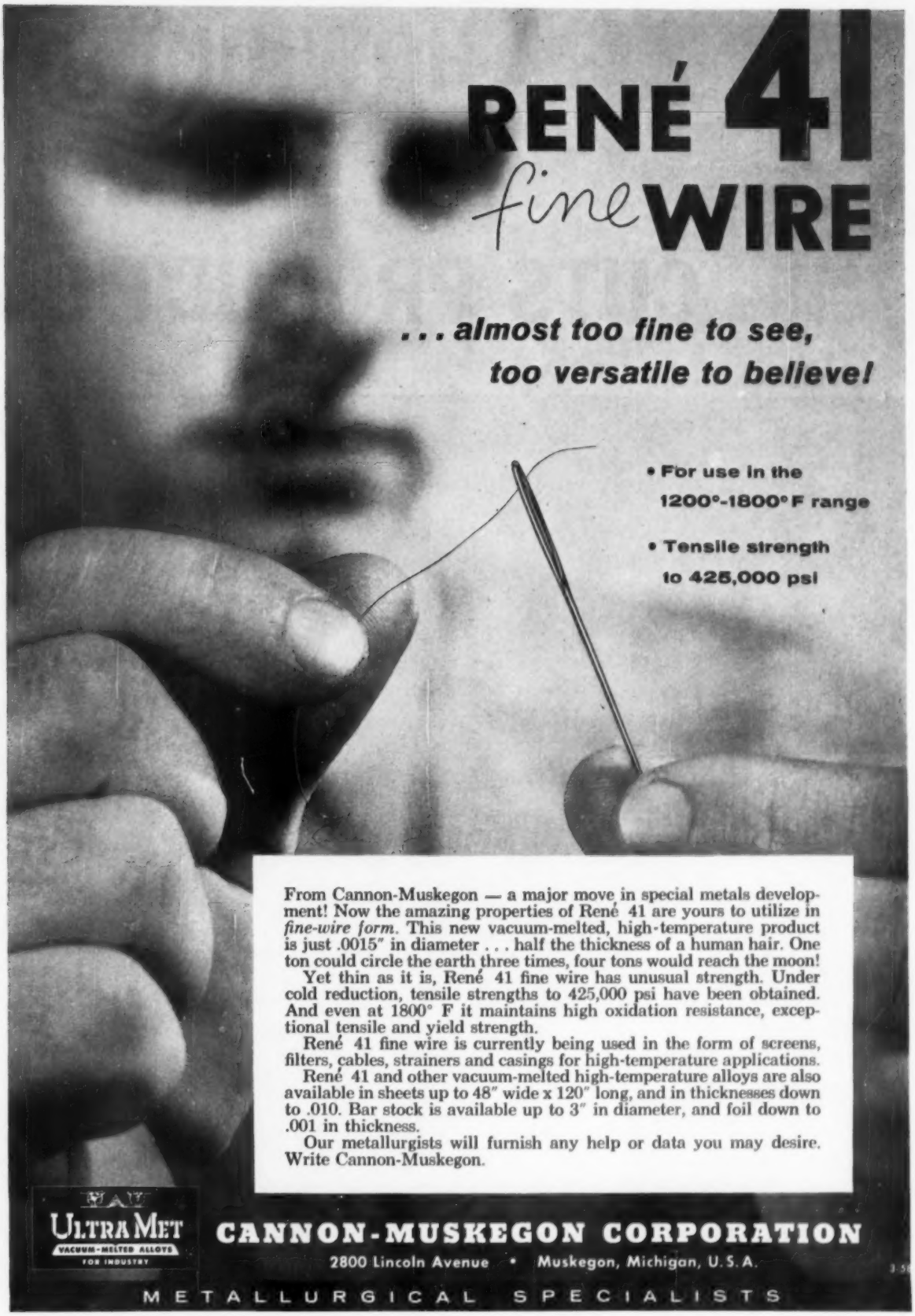
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HOW UNIQUE ALUMINUM CUTS PRODUCTION

SOME OF the 63 Lindberg-Fisher Electric Resistance Reverberatory Holding furnaces in the Ford-Sheffield plant are shown in the permanent mold area. Others with automatic ladling serve the die-casting operation. All use GLOBAR Delta silicon carbide electric heating elements because they lessen contamination, help keep production uninterrupted with simple replacement.

NEW CASTING PLANT COSTS:

Ford Motor Company buys molten aluminum . . . saves with GLOBAR® electric heating elements in 63 holding furnaces

A pace-setting new casting plant built by Ford at Sheffield, Alabama, has actually eliminated the cost of melting aluminum. Molten aluminum is delivered from a nearby plant. That wipes out the need for storage area and the cost of handling pig aluminum. This new concept in casting plant economy is already being adopted by other automobile makers.

Pictured at left are some of the 63 Lindberg-Fisher Electric Holding furnaces developed in co-operation with Ford Motor Co's. engineers. They use GLOBAR Delta silicon carbide electric heating elements because prototype tests proved:

1. Any splashing of aluminum on the silicon carbide element leaves it virtually unaffected, while metal elements tend to deform and drop into the bath causing contamination.

2. Production is not interrupted for replacement because silicon carbide elements are easily replaced.

3. GLOBAR electric elements work at temperatures well below their capacity, while metallic elements would be running at the upper limit of their range.

The original GLOBAR Delta elements have been in use, without trouble of any kind, for 10 months.

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There are many reasons why the use of GLOBAR Delta silicon carbide elements are economical as well as dependable, clean, safe, and quiet. There is no fire or explosion hazard, and exhaust and fuel storage facilities—and costs—are unnecessary.

Only with electric heat can heating cycles be precisely duplicated and temperatures accurately controlled, independent of the atmosphere. Product quality is improved and rejects sharply reduced. Electric furnaces and kilns are compact and space-saving. They can be located in the production line, thereby accelerating production and reducing costs per unit of product.

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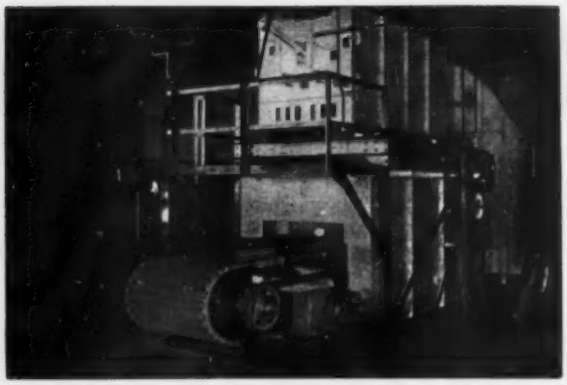

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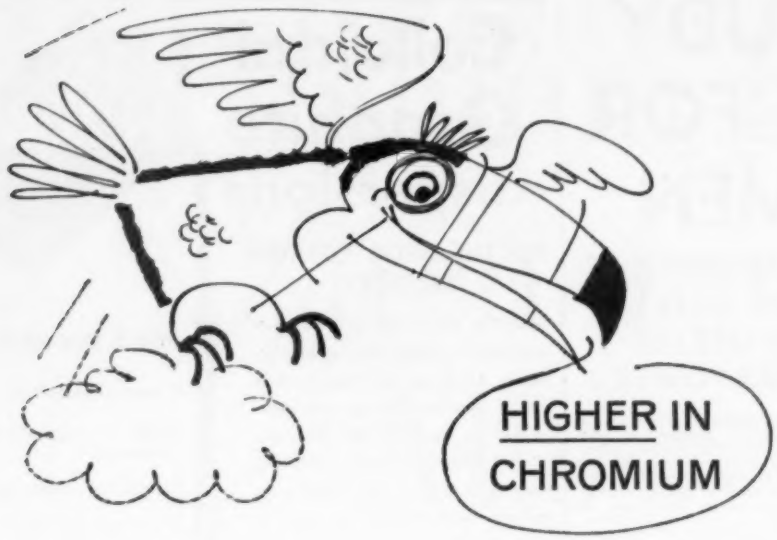

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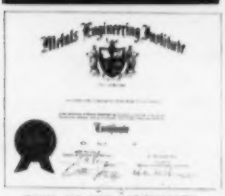

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Sub-Zero	SZH653	6.5	−85°F.	−75°F.	60"	28"	42¼"	47"	15"	16"
Sub-Zero	SZHC657	6.5	−140°F.	−125°F.	60"	28"	42¼"	47"	15"	16"
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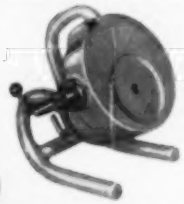

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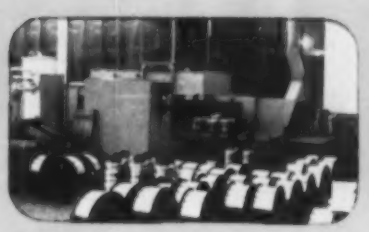

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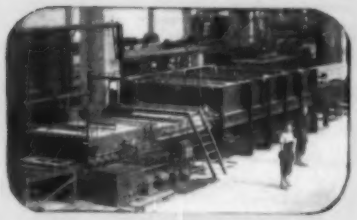

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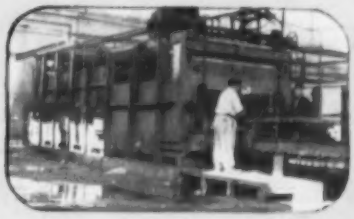
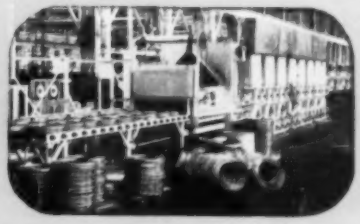


In South America. This EF oil fired pusher type furnace in another South American plant, uniformly heats steel billets up to 60" in length to 2100° F., continuously.

In Mexico. EF direct gas fired special atmosphere forced circulation single stack circular coil steel strip annealers. Each accommodates three 48" x 40" 15,000 lb. coils (45,000 lbs.)



In Canada. Coiled and straight length tubing is uniformly bright annealed in this EF gas fired radiant tube type furnace. Capacity 6,400 lbs. tubing per hour.

In Japan. Part of an installation of large EF gas fired three-stack rectangular coil type forced circulation special atmosphere furnaces for annealing steel strip.

ARISTOLOY

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